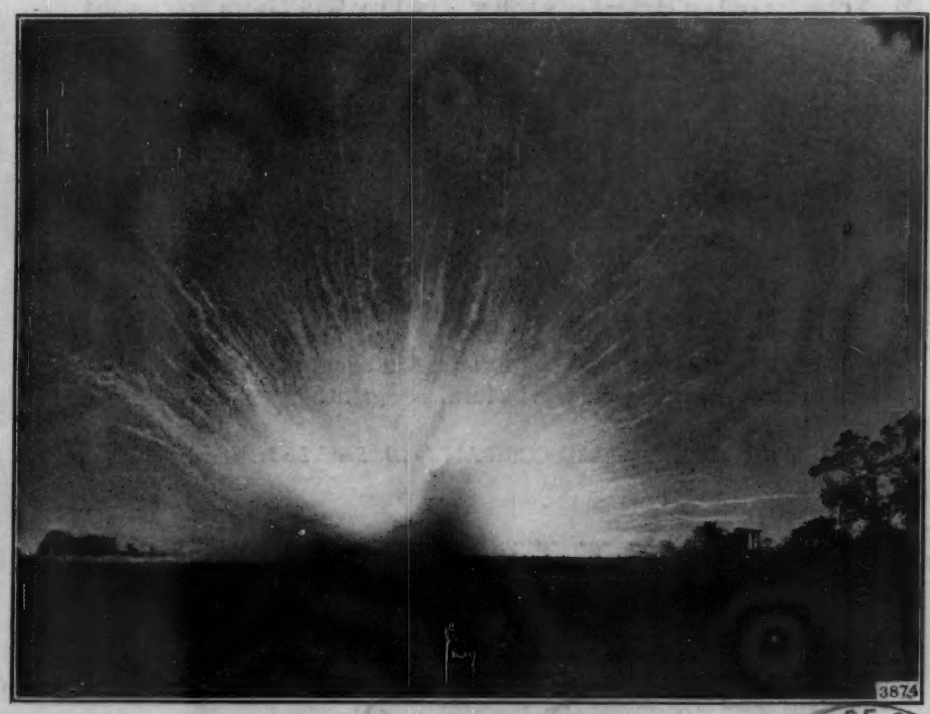
THE TECH ENGINEERING NEWS

MEMBER OF THE ENGINEERING COLLEGE MAGAZINES ASSOCIATED

VOL. VI. NO. 2 MAY, 1925



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From pig to pigment

PIG IRON received its picturesque name in the early days of smelters when the long row of molds connected by slender channels reminded workmen of a sow feeding her pigs. When lead was cast into somewhat similar blocks, though the arrangement of molds did not itself resemble a sow and her young, the castings became known as pig lead.

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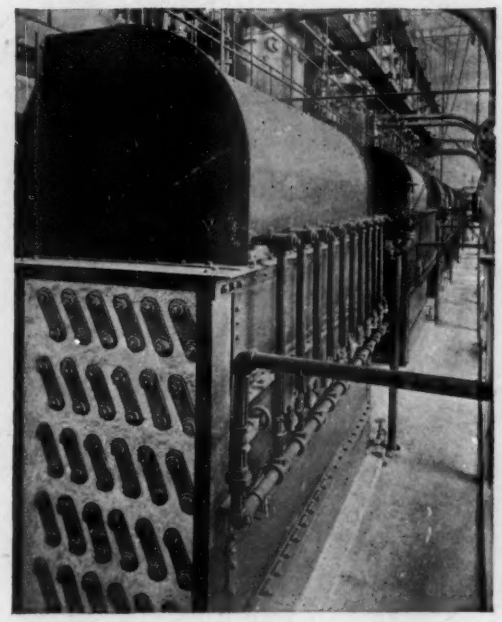

Typical Installation of Foster Economizer

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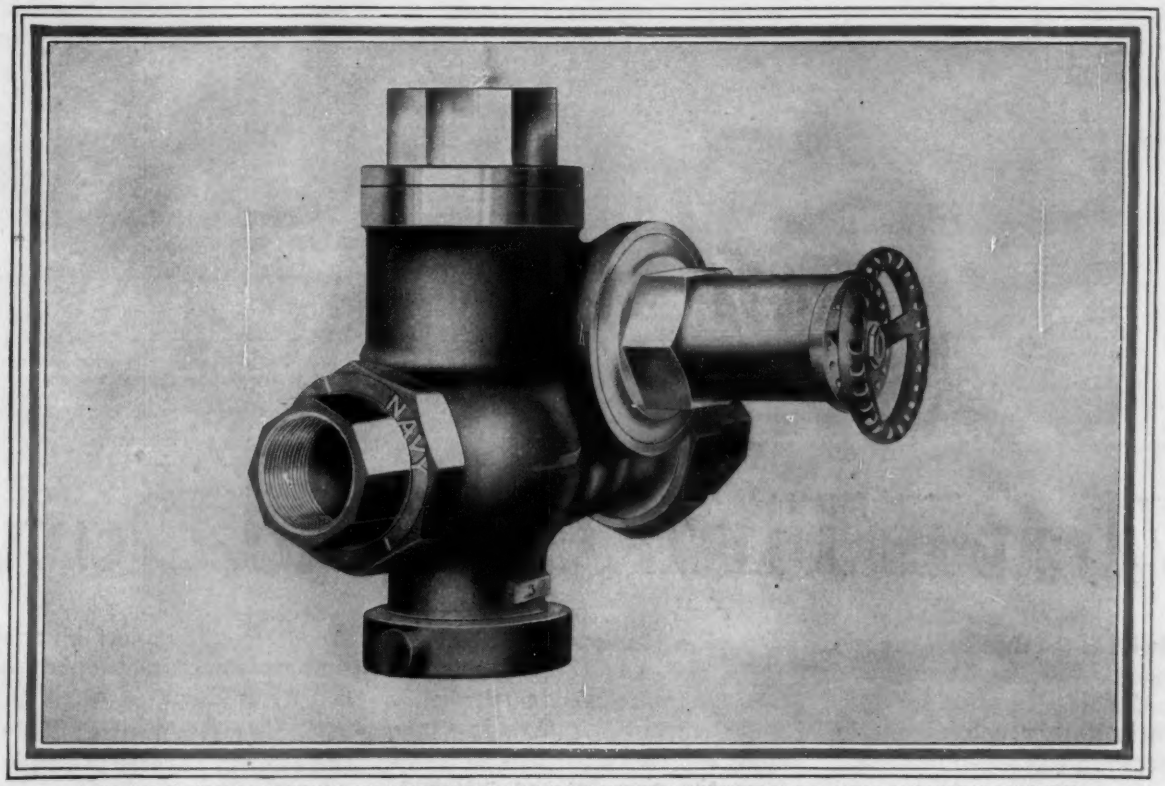

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Tendency toward motion in more than one direction, at one time, is very common mechanically. The wheels of a motor car are spinning around and are also pushed from the side, due to the weight of the car, slope of the road, and the force of turning corners. The discs of a plow, forced forward at an angle, not only revolve, but are thrust sidewise at the earth ahead. And the whirling pulleys in a machine shop are also being whipped from the side by the weaving, swishing belts.

Pure spinning or revolving motion is known as *Radial* motion to engineers. The sidewise or pushing motion is quite naturally called *Thrust*. It stands to reason that *both* the *radial* forces *and* the *thrust* forces, almost invariably combined, must be properly handled by any bearing qualified for most efficient machine design.

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MAY 26 '25

THE TECH ENGINEERING NEWS

Volume VI CAMBRIDGE, MASS., MAY, 1925 Number 2

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THE TECH ENGINEERING NEWS

THE PROFESSIONAL JOURNAL OF THE UNDERGRADUATES OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOLUME VI — MAY, 1925 — NUMBER 2

The Way Up

The conclusions of an investigation to determine how the men at the head of things in this generation have made themselves successful

By WILLIAM H. RIDGWAY

President, The Craig Ridgway & Son Co., Coatesville, Pa.

WHEN a man has decided to go to college and acquire an education—oftentimes at the cost of great sacrifices and self-denial—he does so in order that he may make a place in the sun, or, as is said in every day parlance, "in order that he may get on."

This magazine has asked me if I would tell through the printed page just how a young man with his life before him should go about it to make good. This is an attempt to do so.

This article is an exhibit and not a presentation of an argument. That is to say, it is a statement of facts. The things stated are either so or they are not so. If they are so there is only one conclusion to be drawn and he who runs may read.

During the war, the writer offered his services to the government, along with other good citizens. He was too old to sleep in the mud and fight cooties, so the Government used him in the military camps and navy yards to talk to the boys gathered there from all over the country. At the League Island Navy Yard, where were gathered a great company of young men, mostly from the Middle West where they never saw any salt water, something like this was said:

"When you fellows get out on that big man-of-war lying there at the dock, it will make no difference where you are employed, whether handling ashes down in the hold, or up in the engine room oiling the bearings and wiping up the brasses or a job on the deck with the guns, keeping them in order, or a better job yet in the galley with the cook, or a still higher job up in the chart room with the officers, you know and I know and every sane man knows, you will never get anywhere so far as advancement is concerned and you will not have a particularly comfortable time on the cruise, unless you stand in with the captain."

These were bright young men, and I did not have to elaborate by calling to their attention that this old world of ours after all was nothing but a big boat sailing through the Milky Way and swinging around the sun and no one ever gets very far to stay, so far as advancement is concerned, nor does he have a particularly joyful time on the voyage if he does not stand in with the Captain up yonder, whether he can see him or not!

We take stock in things according to the source from which they come. What Mr. Ridgway tells us in this article we have probably heard from other sources, but this time it comes from a man who is both a civil engineer with the degree of C. E. and a successful business man. As president of the Craig Ridgway and Son Company, manufacturers of steam elevators. Mr. Ridgway is in a position to know big men—men who have attained distinction for themselves in the engineering field, and he has made a study of these men to determine just what is behind their success.

"If I had your company of undergraduates before me," Mr. Ridgway says in his letter accompanying this article, "together with your more recent alumni, I would say to them, 'Boys, if you can get the idea of what I have to say into your system good and proper you will be the men at the head of things in the next generation'. If they should with one voice yell, 'Why?' I would reply, 'Because the men of this generation who are the heads of things have come up this very way.'"

For some 13 years I have been investigating big business. Up to the present time I have not found a single big business of any long standing or of any permanent success but somewhere in it and responsible for that success is to be found a Godly man. He may be a Protestant or a Catholic or a Jew, but he is a man who stands for these high things, and has that "trust" which is stamped on all our gold and silver coins.

I have stood before great gatherings of college men and have challenged them to name me one of the big advertisers of the country, the concerns that spend millions of dollars in the magazines and other places, that I cannot tell what kind of religious activity the man at the head of it is engaged in.

Some time ago a professor in Union College at Schenectady, New York, had me up there to speak to the men of that city. When a friend, who is connected with the General Electric Company, heard I was going to Schenectady to speak, he said to me, "Ridgway, when you get to Schenectady, you want to lay off that hobby of yours, about big business being in the hands of Godly men."

"Why?" I asked.

"Simply because the General Electric Company is an exception to your contention."

"All right," I replied, "we'll see about that. Perhaps it is the exception that will prove the rule."

Here is what I found when I got to Schenectady:

Mr. Rice, then president, is the son of the old Rev. Dr. Rice who for over 50 years has been at the head of the American Sunday School Union in Philadelphia. While I was there I got a copy of the speech which President Rice made at the golden anniversary of his father in that connection.

A vice-president of the Company, Mr. Burchard, is the son of that Rev. Dr. Burchard who spilled James G. Blaine's beans when he said in a

(*Continued on page 82*)

Chemical Warfare

The evolution of the Chemical Warfare Service—The R. O. T. C. Chemical Warfare Unit at Technology, the first and only unit established in the United States

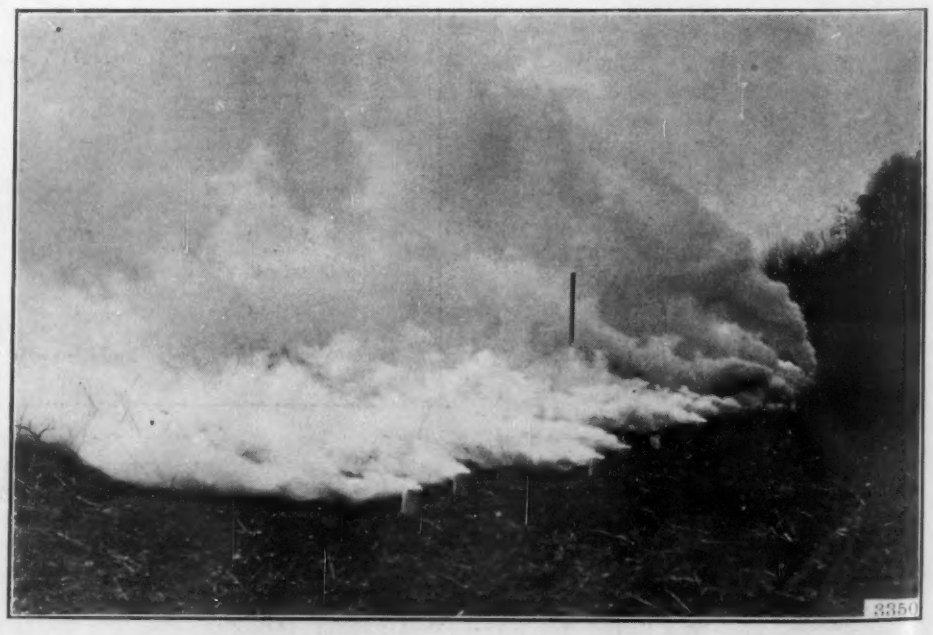
By Thos. Phillips

Captain, C. W. S., D. O. L., officer in charge, C. W. Unit, Massachusetts Institute of Technology

WHEN the United States became definitely committed to participation in the World War, it was at once apparent that the use of chemicals would become a part of the general program. So certain was this that a new regiment, to be officially known as the 30th Engineers, was immediately placed on a recruiting status. This unit, popularly known as the First Gas and Flame Regiment, or "The Hell-Fire Boys," was organized and equipped and sent several companies to France where they were attached to larger organizations of the British and American armies and where they did excellent work. Being listed as engineer troops, they were many times placed on duty for which they were not fitted nor intended, and it was soon seen that a separation would have to be effected, whereby these special organizations would be definitely recognized as specialists and placed upon the duties for which they were especially trained. The regimental designation, therefore, was changed from the 30th Engineers to the First Gas Regiment, which designation applies to the present organization. The formation of combat units which were to have direct contact with the enemy, was a matter with which the officers in charge of the recruiting and training were entirely familiar, in that it was along the lines of their ordinary army duty. The problems of chemical research, the development of offensive and defensive material and the supply of the Gas Regiment and the other components of the army from a base four thousand miles from the fighting front, presented what appeared to be insurmountable difficulties. To cope with these, a Gas Defense Division of the Army was organized, and Professor William H. Walker, of the Massachusetts Institute of Technology, was appointed a Colonel, given charge of a tract of some 35,000 acres of land at Edgewood, Maryland, near Baltimore, and told to there produce a plant for the manufacture and testing of war chemicals and defense material. It is beyond the scope of this article to tell of the difficulties which were encountered and the problems which had to be met and overcome. It should be sufficient to say that Colonel Walker, with the assistance of other able men, many of whom came from the Massachusetts Institute of Technology, established and built Edgewood Arsenal with its laboratories and large scale production plant, its testing fields, shell filling plants, and storage facilities. A branch plant was established at Astoria, Long Island, for the gas defense testing and research division, a proving ground was located at Lakehurst, New Jersey, for the testing of offensive material and the so-called "Mouse Trap" was established at Cleveland, Ohio, for the research, exploitation and manufacture of Lewisite, an agent which gave promise of great usefulness, but which was never actually placed on the front on account of the closing of hostilities by the Armistice. It was this agent which gave rise to the newspaper stories to the effect that we had an agent, one drop of which would wipe out a city, etc. Of course, these statements were entirely erroneous, but so much secrecy was maintained concerning Lewisite that the wildest stories were circulated without refutation.

The difficulties encountered during the war by the officers who composed what was then the forerunner of the Chemical Warfare Service, brought home to those in authority that there would be no time after the declaration of war in which to carry out experimentation and that the time to prepare for defense and offense in connection with chemical warfare material was during peace. The act which established the Chemical Warfare Service of the United States Army as a separate and distinct branch of the military establishment is set out in Bulletin 25, War Department, 1920, Section 12A. It is felt that the statement as set forth in this section is of sufficient importance to be quoted herewith in order that a definite idea of the duties which the Service is called upon to perform may be obtained.

Sec. 12a. CHEMICAL WARFARE SERVICE.—There is hereby created a Chemical Warfare Service. The Chemical Warfare Service shall consist of one Chief of the Chemical Warfare Service with the rank of brigadier general, one hundred officers in grades from colonel to second lieutenant, inclusive, and one thousand two hundred enlisted men. The Chief of the Chemical Warfare Service, under the authority of the Secretary of War shall be charged with the investigation, development, manufacture, or procurement and supply to the Army of all smoke and incendiary materials, all toxic gases, and all gas-defense appliances; the research, design, and experimentation connected with chemical warfare and its material; and chemical projectile filling plants and proving grounds; the supervision of the training of the Army in chemical warfare, both offensive and defensive, including the necessary schools of instruction; the organization, equipment, training, and operation of special gas troops, and such other duties as the President may from time to time prescribe.



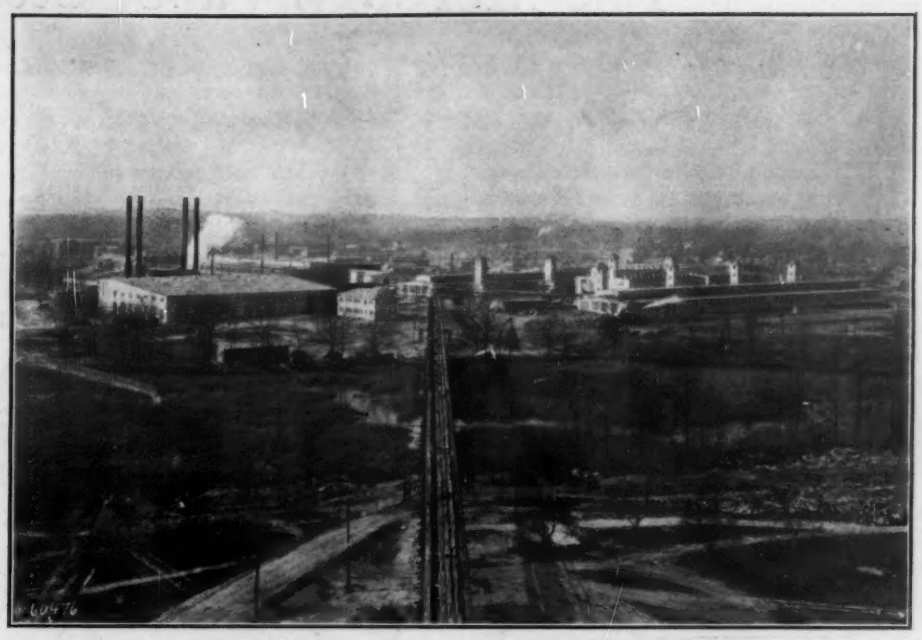
LACHRYMATORY (CN) SMOKE CANDLES

The candle consists of a mixture of chloracetophenone, commonly called tear gas, and smokeless powder. The smoke irritates the eyes.

The Service as at present organized, under several subsequent War Department Orders, has been changed somewhat from the personnel provided in the above quoted act. It consists of about eighty officers and four hundred men of the regular Army with the headquarters in Washington, D. C., under Major General Amos A. Fries, C.W.S., and with the troops and manufacturing plants at Edgewood Arsenal, Maryland. Associated with this nucleus of regular Army personnel is a Research Division, a Plants and Production Division, a Field Testing Division and a Medical Research Division manned by military and civilian personnel, specialists in their various lines.

During the war many difficulties arose in co-ordinating the peace time activities of the chemical industries of the United States with the needs of the Chemical Warfare Service during hostilities. The need of co-operation between the civil and war industries being apparent, it was decided that during peace, co-operation and co-ordination would be established in order that in the event of further hostilities there would be a complete accord between them. The Chemical Warfare Service has given a great deal of study to the best means of bringing about this desired result and there has been established a Chemical Warfare Officers' Reserve Corps. In order that the industries of the nation might be better prepared in the event of another war the country has been divided into Procurement Districts, under district chiefs, charged with the duty of co-ordinating the industries of the district and ascertaining the part each may play to the best advantage of themselves and the government in the event of another war. This should eliminate to a great extent the confusion and duplication of effort encountered in the past.

As is seen from the establishing act quoted above, the problem of the Chemical Warfare Service is a peculiar one in that it has to do not only with the production of chemical warfare offensive and defensive material in time of war, but with the research covering all types of material which might be used not only by our own forces, but against us by an enemy. In other words, we must not only be prepared in the event of need to produce definite results upon an enemy, but we must be prepared to protect ourselves against any and all chemical agents which might be used by the enemy against us. This means that the Chemical Warfare Service has become literally a specialist along the lines of chemical research with regard to the toxic agents. The dye industry and the various chemical industries related to it and the industries which are engaged in the manufacture of pharmaceutical products, are peculiarly related to the Chemical Warfare Service for many of our most effective agents are adaptations of the peace-time products of these industries to war-time use. The research carried on by the Chemical Warfare Service has a definite value in peace time. For example, by our co-operation with the Department of Agriculture in the combat against insect pests, such as the cotton boll-weevil and the locust, we are aiding agriculture in general in its fight against these pests. Here our specialization in poisons is of importance for it is believed that within a short time an agent more effective than calcium arsenate, and perhaps less expensive to produce, will sign the death warrant of the insect which yearly costs the cotton industry great sums of money. The research work upon the treatment of various respiratory diseases has caused great strides forward in the relief of such epidemic diseases as influenza, whooping cough, and the common cold. During the war it was noted that none of the personnel employed in the Chlorine Plant succumbed to the influenza epidemic which swept the country. Thousands of afflicted individuals have since been treated and some 87 per cent have either been cured or greatly relieved by a system of treatment worked out by the Medical Research Division of the Service at Edgewood Arsenal.



PORTION OF PLANT AREA, EDGEWOOD ARSENAL

The buildings in the foreground compose the chlorine plant. This plant supplied all the chlorine used for military purposes during the World War. Chlorine is the chief constituent of many chemical warfare agents.

As the Officers' Reserve Corps developed, and as the membership increased beyond those who had participated in the Chemical Warfare Service during the war and the personnel, who, while not in uniform during the war, were at the same time, actively engaged in the production of war-time material, it was felt that the large technical institutions of the country should provide some means whereby the needs of the Service could be brought to the attention of the students in certain of the specialized courses in order that a nucleus could be provided around which trained personnel could be grouped. The Massachusetts Institute of Technology was one of the first to realize the importance of this co-operation with the Chemical Warfare Service. This was to have been expected, in view of the great assistance it rendered to the Service during the war. On October 25, 1921, the Chief of the Chemical Warfare Service requested authorization from the Adjutant General of the Army to establish units of the R.O.T.C. in Chemical Warfare at a number of institutions throughout the country and placed the Massachusetts Institute of Technology at the head of the list. On November 9, 1921, the Adjutant General of the Army granted authority for the establishment of not to exceed ten Chemical Warfare Units and recommended that these units be established. The Corps Area Chemical Warfare Officer at the headquarters of the First Corps Area, in January, 1922, was directed to conduct a survey of conditions at the Institute with a

(Continued on page 74)

The Mercury Vapor-Steam Cycle

A discussion of the economic limitations of steam and the economic possibilities of the mercury vapor-steam cycle

By Jay Balsbaugh, '24
Electrical Engineering Department, Massachusetts Institute of Technology

THE economic limitations of steam for commercial power developments is due to its pressure-temperature relations. That is under moderate pressures, its temperature is relatively low. The ultimate limit in efficiency of any heat cycle depends upon

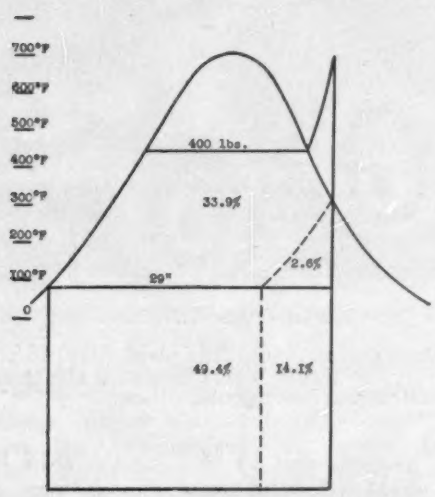


Figure 1

the temperature limits of the cycle and is given by $\frac{T_1 - T_2}{T_1}$. The lower limit is evidently fixed by the temperature of available cooling water and approximates 80°F. The upper limit will depend upon the characteristics of steel, and under desirable pressure conditions may be 1100°F. The theoretical efficiency of the steam cycle can be increased by increasing pressure, but an economic limit is soon reached by reason of the very rapid rise in pressure accompanying a relatively small increase in temperature, the limitations of turbines in transforming heat energy under high pressures into mechanical energy and the greatly increased capital charges accompanying the increased pressures. Superheating the steam permits higher temperatures, but superheating has but a small influence on the theoretical efficiency. It is the temperature of the steam under saturated conditions which primarily determines the limit in efficiency. The temperature-pressure relations of steam and resulting limiting efficiencies are given in the following table:

Pressure		*Eff.*
14.7	212°F	—
300	417°	38.5
500	467°	41.7
1000	545°	46.2
1500	590°	48.6
2000	620°	50.5
3200	706°	53.6

The efficiencies given can be nearly attained at the low pressures, but are impossible of practical attainment at the higher pressures.

The object of the mercury vapor-steam cycle is to make energy

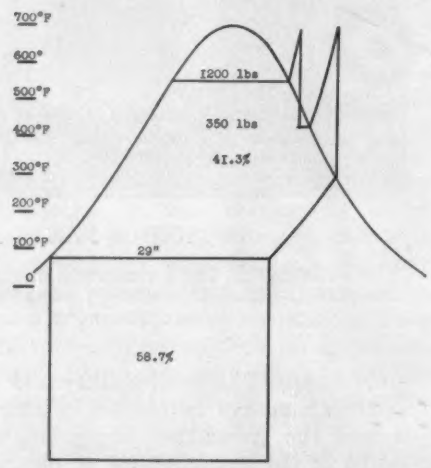


Figure 2

available at temperatures above that possible with steam. The temperature-pressure relations of mercury are desirable and are almost ideally situated with respect to steam for a combination of the two cycles.

Mercury vaporizes at atmospheric pressure at 677°F and at a pressure of 85 lbs. abs. vaporizes at a temperature of 884°F. Its temperature under convenient back pressure for the mercury turbine is suitable for the generation of steam at moderate pressures—300 lbs. to 400 lbs.

It can be shown that the efficiency of

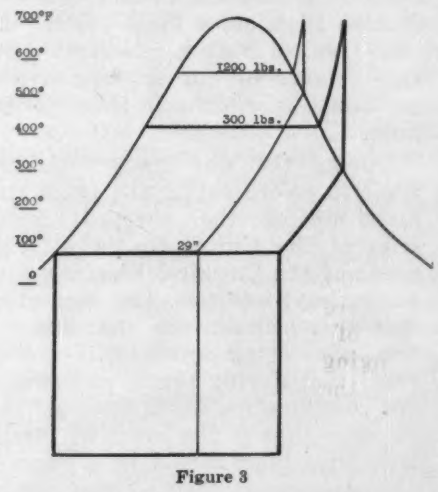


Figure 3

the mercury vapor cycle closely approximates the Carnot or limiting efficiency. Thus, by the use of the two cycles, it is possible to have high temperatures with low pressures and each cycle will give nearly the maximum efficiency obtainable between its temperature limits. Mercury with an initial pressure of 85 lbs. abs. and a temperature of 884°F, expanding to

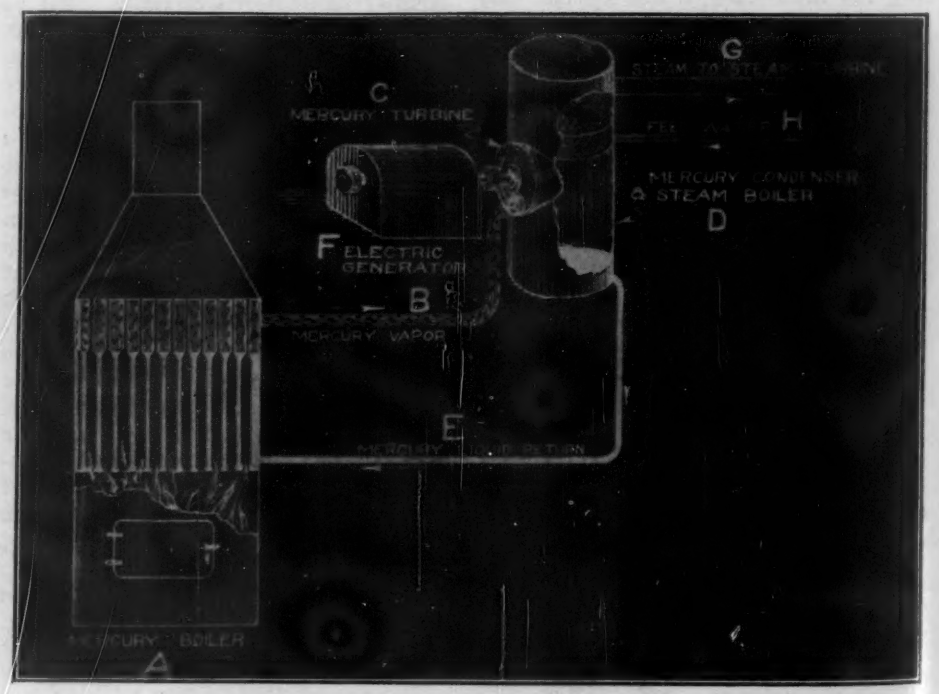


Figure 8
DIAGRAM OF MERCURY-VAPOR BOILER

28.5″ vacuum or 438°F, and generating steam at 300 lbs. abs. and a temperature of 417°F expanding to 29″ vacuum will give an efficiency of 56.3 per cent allowing for a drop of 20°F in the condenser-boiler. The limiting efficiency between these temperature limits is 59.8 per cent and shows that the two cycles closely approximate this efficiency with moderate pressures.

The mercury vapor-steam cycle is illustrated in Fig. 8. Mercury is first vaporized at a comparatively low pressure in the mercury boiler and passes to the mercury turbine which drives an electric generator. The mercury vapor in the mercury turbine is expanded to a convenient vacuum and the mercury vapor is condensed in the mercury condenser by water similarly to the condenser for the steam turbine and the liquid mercury returns to the mercury boiler. However, in this case the water is vaporized and steam can be generated at any desirable pressure in the mercury condenser or steam boiler. The steam under pressure then passes to the steam turbine of usual construction and gives the ordinary steam cycle.

The flue gas in this case is utilized also for heating the liquid mercury, superheating the steam and heating the water before it enters the condenser-boiler. Therefore, the boiler efficiency would approximate the efficiency which is obtained from present steam boilers.

The disadvantages in using mercury are its cost, poisonous qualities and the difficulty in confining it.

Its advantages may be summarized as follows:

1. Desirable temperature-pressure relations.
2. Convenient temperature - pressure relations with respect to steam.
3. High vapor density permits simple turbine.
4. Will not erode turbine blades.
5. Specific volumes at desirable back pressures are relatively small, and thus permit small blade heights in the latter turbine stages.

In order to explain its economic possibilities, the efficiency of various types of steam cycles will be considered, the efficiency of the mercury cycle, and the combined efficiency of both cycles.

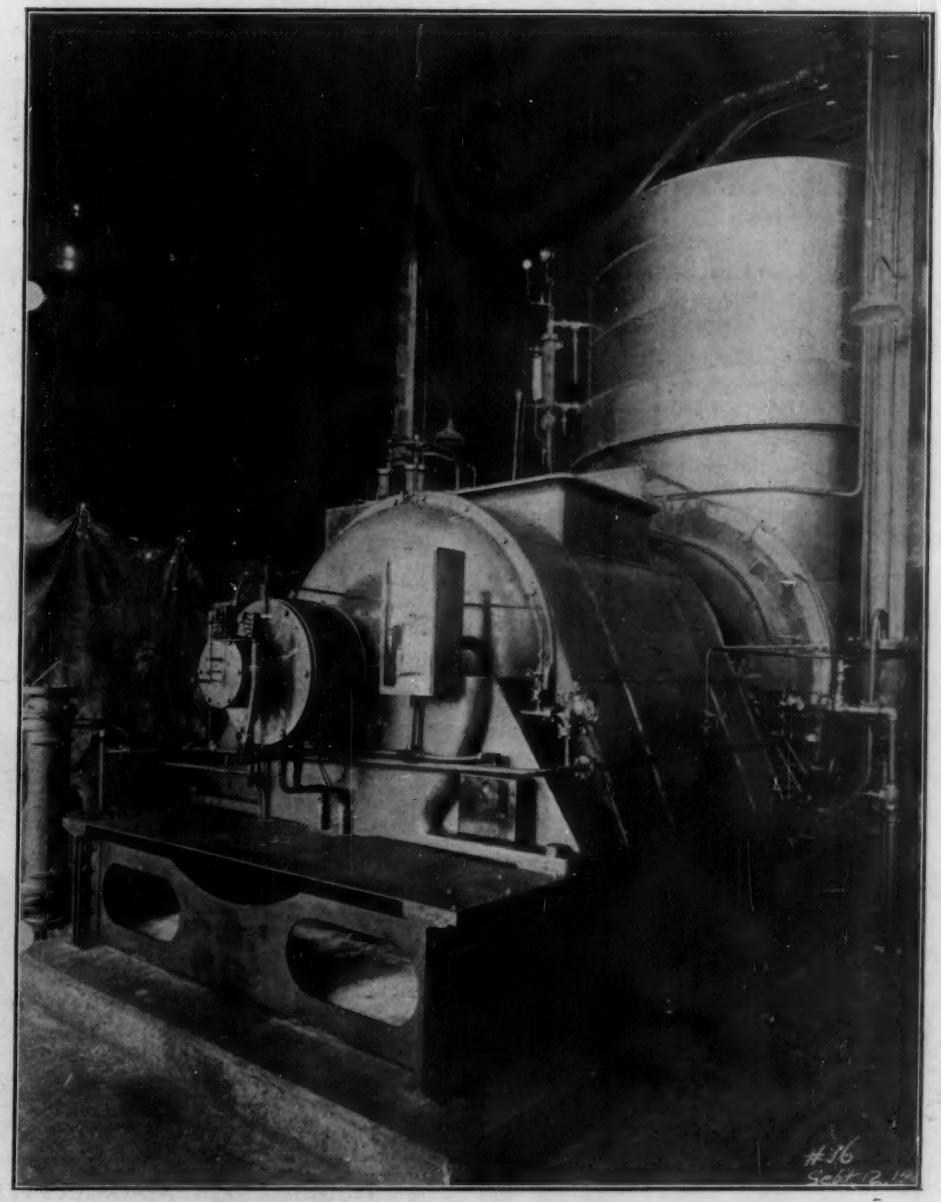
Steam Cycles

The steam cycle which has been commonly used in central stations up to a relatively short time ago is generally known as the Rankine cycle. In this cycle the steam is generated and superheated at constant pressure within the boiler and then expanded to back pressure within the turbine adiabatically and discharged to the condenser. This method of operation represents simplicity, but the theoretical efficiency of this cycle with various pressures is relatively low.

Such a cycle plotted to temperature entropy co-ordinates is shown in Fig. 1 by the full lines. It may be noted that in this case with an initial pressure of 400 lbs. abs. and superheated to 700°F and expanding to 29″ vacuum, the heat available in the turbine is 36.5 per cent and the heat passing through to the circulating water in the condenser is 63.5 per cent.

Curve 1 in Fig. 6 shows the theoretical efficiency of the Rankine cycle with various initial pressure with the total temperature of the steam remaining at 700°F expanding to 29″ vacuum. Thus, it may be noted that increasing the initial pressure from 300 lbs. to 1200 lbs. raises the efficiency from 35.5 to 40.5, or an increase of 14 per eent. This represents a theoretical increase in efficiency and in practice this increase could not be realized due to the decrease in turbine mechanical efficiency occasioned by the large amount of water of condensation present in the latter turbine stages with the higher initial pressure. That is the actual cycle efficiency, is represented by the theoretical efficiency times the turbine mechanical efficiency and the most economical pressure will be that at which this product is a maximum. Higher initial pressures mean lower qualities of steam throughout the expansion due to the lower superheat possible with the higher pressures and consequently the tur-

(*Continued on page 68*)



INSTALLATION OF MERCURY-VAPOR PROCESS UNIT

The unit shown is installed at the Hartford Electric Light Company's plant. The condenser and generator appear above.

The Power and Beauty of Niagara Falls

Proving that great developments can be made at Niagara Falls without injuring its beauty—Means of preventing stream erosion discussed

By Edward H. Sargent, '07
Chief Engineer, Hudson River Regulating District

NIAGARA is synonymous with power and beauty and the writer proposes to discuss here what he believes to be a fact, namely, that the present development of power at Niagara Falls is being made, and greater developments can be made, without in any way injuring the beauty of this, America's greatest scenic grandeur.

Although the first power development at Niagara Falls was by a saw mill constructed in 1725 and which was the only development until 1807, when a grist mill was built, the first serious attempt to develop Niagara's energy was by Horace Day, who in 1861 completed a hydraulic canal which diverted water from a point on the river about a half mile above the falls and emptied at a point one mile below the falls. However, not until the electrical age were the potentialities of Niagara really harnessed and in 1879 a direct current dynamo of about 25-kilowatts capacity was installed to light Prospect Park. In 1877 Jacob Schoellkopf formed the Niagara Falls Hydraulic Power and Manufacturing Company and built a large flouring mill utilizing the water over a head of fifty feet. In 1881 this company installed dynamos, and electricity for the first time was supplied to several companies in the vicinity and for the lighting of the city. From that time on, the development grew apace until last year the Niagara Falls Power Company completed the installation of the three 70,000 horsepower units giving that company an installed capacity of 602,000 horsepower. All of the developments on the American side utilize only the head of the Falls themselves and the rapids above, the most recent development operating under a head of about 215 feet. Until 1918 the two principal developments on the American side were by Niagara Falls Power Company and Hydraulic Power and Manufacturing Company, which were consolidated that year into the present Niagara Falls Power Company. The so-called Niagara plant takes water from a short canal on the American side above Goat Island and discharges it through a long tail race tunnel into the Maid-of-Mist-Pool and has 21 units of a capacity of 5,000 horsepower each. This, one of the earlier plants, has a net head of approximately 140 feet and since the construction of the new plant of this company is used only as a stand-by. The so-called "hydraulic plant" originally got its supply of water through a canal 100 feet wide and 14 feet deep, running from Port Day to the power houses which are situated about one-half mile below the American falls. This canal has recently been supplemented by a tunnel, having a diameter of approximately 30 feet, discharging into the forebay of the same plant. This plant, which really includes three plants, has an installation of approximately 500,000 horsepower. The last three turbines installed in this plant have a capacity of 70,000 horsepower each with an efficiency of 93 per cent.

Developments were made on the Canadian side, at first by private companies and later by the Hydro-Electric Power Commission of Ontario, until there is now installed on the Canadian side a total of 950,000 horsepower. The development on the Canadian side is greater than on the American shore for two reasons; first, the limitations of the treaty between the United States and Great Britain, which will be discussed later, permitting a diversion of 36,000 cubic feet per second on the Canadian side and 20,000 cubic feet per second on the American side; secondly, because the most recent Canadian development, that of the Hydro-Electric Power Commission has a head of 304 feet which is all of the fall between Lakes Erie and Ontario, which is economical of development, thus using not only the head in the Falls themselves but also the head in the Whirlpool Rapids as well. It should be noted however, that only legal difficulties have prevented a supplemental development on the American side, which would utilize the diversion of 20,000 cubic feet per second under a head of about 80 feet. Such a development which would have a capacity of over 200,000 horsepower and together with the existing developments at the Falls themselves would utilize practically all of the available head on the American side.

The average flow of the Niagara River is 212,000 cubic feet per second and owing to the regulation from the Great Lakes, the river is perhaps the most uniformly flowing large river in the world, the only large variations being caused by heavy winds on Lake Erie or ice gorges. As the river is an international stream, forming as it does the boundary between the United States and Canada, it naturally follows that any diversions must be subject to agreement between the two countries. The developments on the

MODEL OF THE NIAGARA RIVER SHOWING "ISLAND SCHEME"

Conditions shown illustrate an outflow from Lake Erie of 200,000 cu. ft. with a diversion of 100,000 cu. ft. around the falls, with the remaining 100,000 cu. ft. evenly distributed over the crest of both falls.

American side were made pursuant to grants from the State of New York and permits from the United States Secretary of War. As the power developments increased, fear was expressed that such developments were seriously injuring the scenic beauty of the Falls and in 1905 a campaign was started to prevent further power developments. Following this agitation, Congress passed in 1906 the Burton Act, which restricted the diversion of water on the American side to 15,600 cubic feet per second. This act also requested the President of the United States to negotiate a treaty with Great Britain, providing, "for such regulation and control of waters of Niagara River and its tributaries as will preserve the scenic grandeur of Niagara Falls and of the rapids of said River." Such a treaty was negotiated, ratified by the Senate, ratified by the President, by Great Britain, and proclaimed to be in force from and after May 13, 1910.

The terms of this treaty limit the diversion of water for power purposes above the falls to 20,000 cubic feet per second on the American side and 36,000 cubic feet per second on the Canadian side. The principal reason for this unequal allocation of diversion was because one of the largest developments on the Canadian side was built by American capital and the power therefrom was exported to the United States. Further, the treaty stated, "that it is expedient to limit the diversion of waters from the Niagara River so that the level of Lake Erie and the flow of the stream shall not be appreciably affected. It is the desire of both parties to accomplish this object at the least possible injury to investments which have already been made in the construction of power plants on the United States side of the river... and on the Canadian side of the river..." and the allocations as made presume to accomplish this.

As stated hereinbefore, the average flow of the Niagara River is about 212,000 cubic feet per second, varying from about 170,000 c.f.s. to 260,000 c.f.s. It is thus evident that the treaty limitations totalling 56,000 c.f.s. permit a total diversion of about one-quarter of the average flow. Elaborate measurements taken by the United States engineers in 1908 at the time when the American power houses were temporarily shut down, show that the difference in depth of the water going over the Falls when the power houses were in operation and when idle was less than an inch. This difference in elevation and the corresponding difference in flow was not visible to the eye. Photographs of the Falls taken in 1876, 1885 and 1888, when there were

AIRPLANE VIEW OF THE NIAGARA RIVER
The view is taken from the Canadian side looking downstream.

no electric power plants in operation at the Falls; in 1900 and 1905, when the amount of power in use was about 100,000 horsepower and in 1910, when the amount was over 330,000 horsepower, show that under similar conditions the diversion of water has not reduced the scenic gradeur of Niagara Falls.

Much has been written about the destruction of the beauty of the Falls of Niagara, particularly of the Horseshoe Falls, by reason of the diversion of water for power purposes. The Horseshoe Falls discharges sixteen times as much water as the American Falls and the greater part of the flow over the Horseshoe Falls is discharged at the very apex of the Falls. It is this concentration of flow that causes the recession of the Horseshoe Falls, which averages over 5 feet a year, and the blame for which has been imputed to the diversion of water. There has been a considerable recession of the crest of the Falls since 1764 when the first survey was made. In a recent report, Colonel Warren, (Colonel Warren's Report was a summary of a most exhaustive report prepared by W. S. Richmond M. I. T. '05), of the Corps of Engineers of the United States Army, suggested that remedial works be constructed in the center of the Rapids just above the Horseshoe Falls to deflect the water over the sides and heels of the Horseshoe, which are now partly dry due to the recession of the Falls and the concentration of flow at the apex. These works would cause the entire crest of the Fall to erode uniformly and incidentally would make more perfect this emblem of good luck. If such remedial works are built, Colonel Warren recommends that the diversion around the Falls be increased to at least 80,000 cubic feet per second and states that this diversion would cause no damage to the scenic beauty of Niagara.

The total drop from Lake Erie to Lake Ontario is 336 feet of which 165 feet is concentrated in the cataract itself and 55 feet is in the rapids above so that within a distance of one mile there is available a total head of 220 feet; this combined with the 94 feet fall in the Whirlpool Rapids creates a head of 314 feet, all of which is economic for development and which with the total flow of the river would produce over 6,000,000 horsepower. A diversion of 80,000 cubic feet per second as recommended by Colonel Warren could be made to develop about 2,500,000 horsepower if the total fall is utilized. As it requires from eight to ten tons of coal to generate a horsepower for a year, such a development would cause a saving of from 20,000,000 to 25,000,000 tons of coal per year. The existing plants, under the present treaty limitations, develop about 1,200,000 horsepower.

The late John L. Harper, at the time of his death Chief Engineer of the Niagara Falls Power Company, gave a great deal of thought to the preser-

(*Continued on page 78*)

Water-Cooled Furnaces

A discussion of the recent tendency in boiler practice to replace fire-brick refractories with water-cooled tubes

By Col. H. D. Savage

Vice-President, Combustion Engineering Corporation, New York, N. Y.

It has been apparent for several years to those interested in the rapid developments being made in power plant work, that, although the Refractories Manufacturers' Association through the fellowship they have established at the Mellon Institute as well as the Bureau of Mines, have been doing excellent work in the investigation and development of special refractories, refractories and furnace materials have not been keeping pace with the strides being made in other features of this development. The higher settings, higher ratings and higher efficiencies now being made have placed a duty upon boiler furnaces that cannot be met satisfactorily by the refractories available or of common and standard use, for while it may be possible to develop in the laboratory high heat-resisting materials, these same materials when put into service may, due to stress of operation or ever-present fluxes in ash, fail entirely to meet the requirements without some artificial aid. This led in the beginning to the development of ventilated blocks, of which there are a number of different types on the market.

The more recent and complete development, however, covers:

1st. Hollow wall refractory furnaces.

2nd. Steam-cooled walls.

3rd. Water-cooled walls.

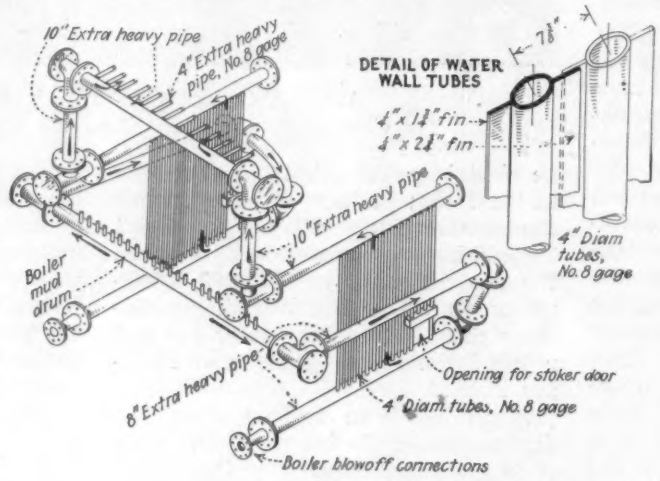

10" Extra heavy pipe
4" Extra heavy pipe, No. 8 gage
DETAIL OF WATER WALL TUBES
4" x 1½" fin
4" x 2½" fin
7½"
4" Diam tubes, No. 8 gage
10" Extra heavy pipe
Boiler mud drum
8" Extra heavy pipe
Opening for stoker door
4" Diam. tubes, No. 8 gage
Boiler blowoff connections

Figure 1
ISOMETRIC VIEW OF SCREEN INSTALLATION

While the hollow wall furnace was a tremendous step forward, its application is more practical with powdered fuel than with stokers, so that it meets immediately with limitations. The steam-cooled walls may, of course, be applied to any type of firing, but naturally the amount of cooling obtained from this source must be limited, as the area possible to expose in the furnace is governed by the amount of superheat required, and up to the present time results obtained would indicate this method of cooling to be not yet out of the experimental stage.

The completely water-cooled furnace or a combination of water-cooled and refractory furnace would seem to present the greatest possibilities for future interest.

This paper will deal with one type of water-cooled furnace, namely, the finned type, or as it is now called, the fin furnace. This furnace has been applied to both stoker and pulverized fuel installations, and while accurate data covering the net effect of such walls on capacity and economy is too meager from which to draw conclusions, it is quite possible to discuss it from a practical operating standpoint, since three water-cooled furnaces over stoker fires have been in operation at the Hell Gate plant of the United Electric Light & Power Company for something over a year, and six similar furnaces in connection with pulverized fuel firing have been in operation at the Sherman Creek plant of the same company for several months. These nine units have been in regular service since their installation and since no unusual operating difficulties have developed, it may be proper to assume that they are no longer in an experimental stage and that while, of course, there will be refinements and further developments, the fin furnace is at present a thoroughly reliable article of commercial merit, capable of producing immediate results in the matter of upkeep reduction and of lessening outage time due to present necessity of furnace brickwork repairs.

When the finned tubes were applied at Hell Gate, prophecies were made as to the burning off of the fins, the erosion of the tubes and the reduction of efficiency through too much cooling in the furnace. None of these prophecies have been fulfilled. The original boiler at Hell Gate has been in operation since December, 1923. The tubes and fins show no erosion, the corners of the fins being just as true and square today as when originally applied. The boiler has been in operation up to approximately 600 per cent of rating, and efficiencies have been published from tests of these boilers, which show as high as any that have been produced in the country, which would indicate that the losses due to excessive cooling looked for have not occurred.

Many attempts have been made in the past to water-cool furnaces. Most of the designs have embodied a combination of water tubes and brick, but the indications are that the complete metal furnace has several advantages over anything yet offered.

Welding of the fins onto the tubes makes a complete bond, so that the transfer of the heat through the fins and tube is almost equal to the transfer through the tube itself. While no data is available at the present time covering actual results obtained, some tests are now being planned which will furnish data covering velocity, absorption, radiation, etc. We may, however, at present, use as a comparison, some tests recently made on a Lepulco water screen at Cahokia, which indicate an absorption on the horizontal tubes of approximately 80,000 B. T. U. per square foot, and on the vertical side tubes of close to 75,000 B. T. U. per square foot. This would indicate that the vertical side tubes of the water wall have a very efficient absorption surface and that the cooling does not extend into the furnace a sufficient distance to interfere in any way with the efficiency of combustion. It has not been found that the capital expenditure required for fin furnace construction is greatly in excess of the latest type of refractory furnaces. In fact, if credit is given for the additional heating surface gained, the cost chargeable to furnace will be slightly less than with other methods.

For the benefit of those who are not familiar with the furnace design it may be well to briefly describe it.

Drawing No. 1 shows an isometric view of the screen installation at Hell Gate and drawing No. 2 shows a cross section of the same installation.

These side walls consist of 4-inch tubes arranged vertically on each side of the furnace and spaced on 7-inch

centers. Each tube has two longitudinal steel fins welded on it diametrically opposite each other, and when placed in the boiler furnace, the fins overlap, thus presenting a continuous water-cooled surface to the radiant heat of the furnace. The lower portion of the tube is covered by fireclay tile for a short distance above the stoker. This extends along a horizontal line the entire length of the furnace. In future installations, the refractory wall may be entirely eliminated and partially replaced with metal blocks.

The water in the tubes forms a part of the regular boiler circulation, the lower end of the tubes being connected by headers leading to the mud drum. The upper end of the side-wall tubes are connected to a header, which, in turn, discharges into the boiler drum through a special set of nipples and headers in front of the drum.

The water-cooled side walls not only replace practically all the brickwork in the side walls, but afford considerable protection to the front and rear walls by absorbing the heat which they reflect, thus lowering the temperature of the face of the wall.

To anyone familiar with the difficulties of brickwork maintenance the logic of the water-cooled walls is at once evident Not only is the problem of brickwork maintenance in large boiler settings an item of considerable expense, but the loss of capacity of steam-generating equipment rendered idle by necessary repair periods is of even greater importance. In the older plants in which smaller boilers and furnaces are employed, it is not unusual to complete a major brickwork repair job over a week-end or holiday period. With the larger settings, several days are required, and each boiler represents a larger percentage of the total steaming capacity than it did in the older stations having a larger number of small boilers.

In days past, due to small units, the outage due to necessity for brickwork was not such a serious matter, and the necessities of stoker operation required considerable outage for stoker repairs and upkeep so that brickwork maintenance might be done during these periods.

Now that the tendency is to larger boilers and pulverized fuel firing with the contingent ability to operate for long periods without the necessity for maintenance shutdowns caused by firing equipment, and since any outage on larger boilers must of necessity be for longer periods, it seems well to do away with the limiting factor which brick walls would naturally place upon such an installation.

Another strong tendency at the present time is toward pre-heating combustion air. Pulverized fuel firing in combination with air heaters makes possible very high ratings and produces naturally very high efficiencies, which means a very intense heat in the furnace, making the necessity for water-cooled walls practically imperative. With water-cooled walls installed under such conditions, the units may be kept on the line for long periods without any more liability of shutdowns than is caused by the boiler itself under present conditions.

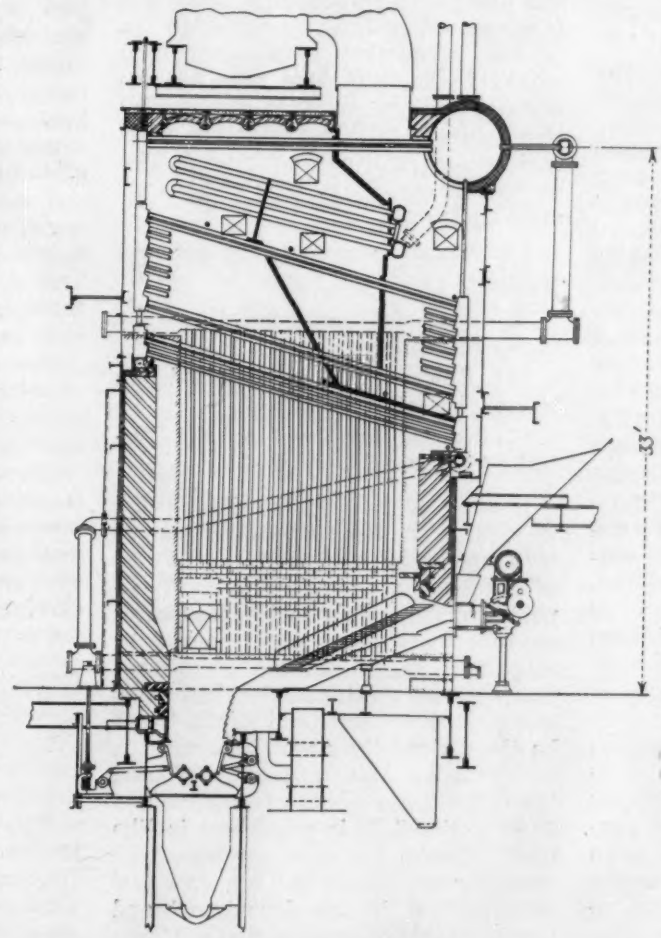


Figure 2
CROSS SECTION OF HELL GATE INSTALLATION

A water-cooled furnace in combination with an air-cooled refractories furnace is now being applied to one of the 1800 h.p. boilers at the Cahokia station of the Union Light and Power Co. of St. Louis, Missouri. Considerably over half the side wall is screened as well as the back wall. It has been suggested by some that too much cooling may be obtained. All of the operation so far shows that there are no disadvantages from cooling as has been implied and we know from experience that completely water-cooled furnaces, such as locomotives and Lancashire boilers are used at very high ratings with excellent efficiencies.

The fin furnace may be applied to any type of firing, either pulverized fuel, fuel oil or stokers. It may be applied to existing plants on either large or small boilers and in many cases may be applied to present installations without making any changes in the settings, by simply installing the tubes in front of the present brick work which would serve as a suitable backing and would practically end the necessity for the continuous patching and repairs which of necessity are being frequently made under present conditions if solid wall furnaces are being used and any sort of efficiency or capacity is being obtained.

We very frequently hear engineers in charge of stations say, "Oh; well I don't have much brickwork repairs and I wouldn't be justified in putting in water-cooled furnaces." This statement, if true, would only mean one thing; either that a large capital expenditure has been made in order to operate boilers at a low rating in order to save brick work or that combustion efficiency is not what it should be.

The high cost of boilers and accessories, and the proven ability of modern firing methods to produce high ratings for long periods with high economy, has made obsolete rating methods of not more than a year ago and the progressive engineer must discard his boiler horsepower calculations and figure strictly from a standpoint of evaporation per square foot of heating surface, and bear in mind constantly that the pounds of coal possible to fire efficiently under a boiler today bear no relation to his calculations of yesterday. This is most strikingly illustrated in the case of a new station projected for the eastern part of this country where the original figures made on the basis of underfeed stokers operating under the most favorable conditions, showed a necessity for forty-four boilers of approximately 15,000 square feet heating surface each. The present figures revamped to

(*Continued on page 90*)

A National Headquarters for Facts

The remarkable clearing house of business statistics being developed at Babson Park, Massachusetts

By LEROY D. PEAVEY, '98
Vice-President, Babson Statistical Organization, Babson Park, Mass.

HERBERT HOOVER has said that any problem can be solved if you have the facts. At Babson Park, Mass., in the towns of Wellesley and Needham, Roger W. Babson, '98, is working for the establishment of a national clearing house for business statistics. Beginning with his Statistical Organization some twenty years ago, which has practically incited the whole world to a study of present and future business conditions, he has dreamed and planned and built till a miniature statistical village is already arising from what was five years ago only plain, hill and forest.

The scope of this undertaking does not become apparent until you have tramped over the 200-acre "Campus" of the Babson Institute and the scores of additional acres to be devoted to statistical laboratories, offices and homes, when the interesting project is completed. At present the office and research buildings, including the great United States Map building now in construction, number twelve. Future plans call for about one hundred structures in the coming years, if the vision of the founder is realized.

On its third anniversary this unusual development embraces an investment amounting to nearly a million dollars. Chief among the projects is the development known as the Babson Institute, organized under the Educational Laws of the Commonwealth of Massachusetts. Founded only six years ago, the Babson Institute has already come to occupy a unique position among the leading business men's schools of America. Daring in conception and method, it is known among business executives as a center of practical training for business administration.

It is designed for those who, through inheritance or position, are destined to occupy positions of trust and responsibility. It is able by its unique method of training, to graduate in two years a man specially equipped for an executive position in connection with a large business enterprise or the financial problems of a large estate. Those who for any reason cannot give full two years, receive in one year a thorough practical training in the true fundamentals of business.

The first year's work is in four fundamental divisions of business activity, and the second year's work consists of detailed training in one particular line of business. The Institute is under the direction of George W. Coleman, former president of the Associated Advertising Clubs of the World, and one of the best known executives in America. The Institute does not attempt to give the same detailed cultural courses as are given in colleges. The purpose is to emphasize and impress upon the student the fundamental principles involved in finance, production, distribution, and personal efficiency. Men who are inoculated with these principles can by themselves in later years gather what further information is required. The work is grouped generally under four main divisions:

(1) Practical Economics and the Handling of Commodities.

(2) Financial Management and the Care of Property.

(3) Business Psychology and the Influencing of Men.

(4) Personal Efficiency and the Control of One's Self.

Instead of having the instruction in each of the departments extending throughout the nine months, the student takes up the work in each department separately and concentrates on that work alone for a period of three months. At the end of this period, if, for instance, he has been studying "Economics and Production," he then gives the next three months to "Finance and Investments," and the third three months to "Sales and Distribution." This procedure is like that followed by a young man who goes into a business and spends a few months, first in one department and then in another, instead of taking an hour or so a day in every department.

The students are divided into groups. Each group takes the first three months' work in one of the departments and then changes to another department for the next three months. Under this plan the department head can personally supervise the activities of his men. Furthermore, it makes possible inspection trips to factories, industrial plants and business houses. These visits are an important part of the work.

The Institute runs on a business schedule. The students all report at 8:30 in the morning and outside of the luncheon period, work until 5:00 in the afternoon. All group meetings are held in the forenoon, afternoons being left free for studying, special research work, or trips to factories and other organizations. Prompt and regular attendance at class and conference is required.

A time clock is used by everyone in the Resident School, not so much with the idea of checking attendance as to develop habits of regularity and punctuality. When students are away from the building on special trips, they are expected to leave word at the office, just as they would in business. Each student works at a desk with telephone and dictates into a dictating machine his letters, themes and analyses, the idea being to give him, as far as possible, the atmosphere of real office procedure.

The purpose is to get away from the traditional lecture system of instruction and emphasize "laboratory work." This does not preclude occasional lectures by the instructors, but emphasizes the conference or discussion idea. These small groups of fifteen or so gathered around the table and together working out their problems typify instruction at Babson Institute.

The Institute was founded with a conviction that one great secret of business success is the right kind of personality. To point out and try to develop the main essentials of a successful personality is a fundamental purpose. A special effort is made to develop character, and improve the bearing of each man. The fundamental purpose is to enable the student to better understand himself, his employer, his employees; in fact, to get along with people.

The second-year course continues the work by adding to these essential fundamentals the technical details of some one line of business, under the direction of the noted statistician, Dr. Frederick L. Hoffman, formerly vice-president of the Prudential Life Insurance Company. Each student in this research work follows a course designed to fit his individual needs. Extensive business research in various industries is thus being continually carried on. Especially important and interesting is the intensive work now going on in the second-year group to improve distribution methods in many lines.

The Extension Division provides Babson Institute training for those who, because of active business connection, obviously are unable to attend the Resident School. This work is divided into a Junior, or Fundamental Course, and a Senior, or Advanced

Course, both operated along accepted methods of correspondence and instruction, and supplying hundreds of executives and rising young men with the training so invaluable to men in these positions.

With the co-operation of business associations it is planned to make the new Institute not only the training ground for the younger executives, but a real center for great industries. Here it is planned that business research will be carried on under the direction of leading business scientists. Here the executives of our great businesses may gather for conference and the study of individual problems. Here practical plans will be worked out to insure manufacturers and merchants reasonable prosperity.

Under the guidance of one of America's foremost landscape architects, John Nolen, plans have been carefully laid out to take care of developments for years to come. Each new structure and development will fill its allotted place in the general controlling scheme. The plans, if carried to fulfillment, call for a separate campus for each related group of activities. The first is known as the Student Campus. Here are located the buildings devoted to instruction purposes and dealing with economics, psychology, business administration, industrial management, finance and religion. The plans call for a second campus, to be known as the Research Campus. There are projected buildings for forest products, agricultural products, animal products, and mineral products. The third campus is to be known as the Distribution Campus and calls for buildings devoted to the forty-eight states and the leading markets of the world. In addition to these three groups, there is also projected a public conference campus, containing an auditorium, dining hall, industrial arts building, gymnasium, dormitories, and boy scout camps. It is planned to accommodate conference delegates and their families in such a way that Babson Park will become an ideal spot for national conventions of serious purpose.

The building program is already well advanced along all these lines. On the Student Campus an auditorium has been erected and is already in operation. It is an attractive brick structure of Colonial style, accommodating a larger audience than any building between Boston and Springfield. For two years this has been the center of an annual summer conference for business men attended by representatives of every leading industry of almost every state. When the galleries are utilized it provides seating capacity for about 1,600. It has received wide-spread favorable comment for its dignity and charm of appearance.

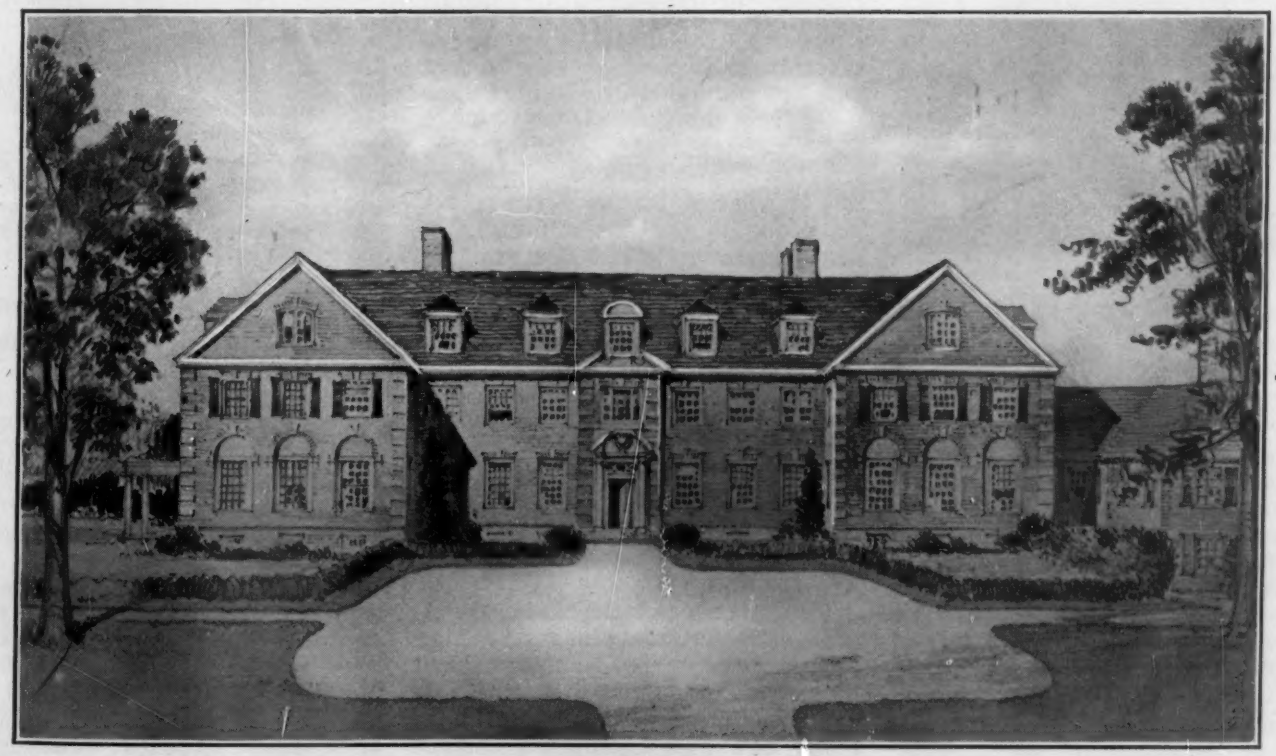
Other buildings, already constructed, include an administration building, a large three-story structure for the first-year students, a companion building for the second-year research work, and an attractive and efficient gymnasium. An outstanding feature of the group is the commodious club house, a Colonial brick structure of about thirty-five rooms, with ample dining facilities. The rooms are handsomely equipped, each having bath, telephone, and radio facilities for the convenience of student patrons and the general public. In this connection, among the features being developed are the picnic grove, with open fireplace, about seven miles of bridle paths, a large bird sanctuary, and eventually, one of the best 18-hole golf courses in New England.

In the matter of making business and financial facts available to the business man and investor, a considerable number of individual agencies are already located at Babson Park and are in full operation.

For instance, the famous Poor's Publishing Co. has already moved from New York to Babson Park, bringing its research department and extensive resources and data on corporations and securities. The coming of this organization to Babson Park means not merely the location there of a national financial library, but likewise makes accessible a vast fund of personal experience and research.

Authorities are generally agreed that the central problem in business is no longer production, but distribution. With this fundamental need in view, there has been established at Babson Park the Better Service Co., which provides an efficient organization for

(*Continued on page 80*)



CLUB HOUSE AT BABSON PARK

Modern Testing of Firebrick

Showing methods of testing refractories in Heat Measurements Laboratories at Massachusetts Institute of Technology

By GORDON B. WILKES, '11
Associate Professor of Industrial Physics, Massachusetts Institute of Technology

IN the early days of firebrick manufacture when temperatures in boiler settings seldom went above 2400°F., and coal was practically the only fuel, the problem of suitable refractory brick was a relatively simple one, and an occasional determination of the fusion point was all that was necessary to decide upon a satisfactory brick.

When oil and powdered coal, with increasing knowledge of proper combustion, were introduced, the choice of suitable refractories became more of a problem. Very much higher temperatures were obtained and today it is not unusual to demand that a firebrick withstand a temperature of 2900°F. In addition to this very high temperature, when oil or powdered

FIREBRICK WALL
Showing the condition of the wall after a laboratory test of 8 days at 3000°F.

coal is used, we have sudden changes in temperature which frequently cause more damage to the refractory than the high temperature alone. Also with relatively low temperatures, the fuel ash was not melted to any great extent and consequently there was very little trouble due to the molten slag attacking the brickwork. With temperature between 2700°F. and 2900°F. this action is frequently very serious, and increases rapidly with increase of temperature. The effect of the molten ash varies also with the type of fuel, for example the action of ash from Indiana or Illinois coal is far worse than from the better grades of Pennsylvania and West Virginia coals.

The size of furnace chambers has also been enlarged so that now we have furnace walls forty feet high and sometimes very thin, which increases the structural difficulties. The use of insulating brick has also added to the demand for good refractory brick because the average temperature of the firebrick in an insulated furnace wall is much greater than in an uninsulated wall. In fact, one reason why insulating bricks are not used to a greater extent today is on account of the firebrick not having the necessary physical properties to withstand the increase of temperature. The cost of boiler settings is also a very appreciable item running into thousands of dollars for each boiler. If the life of a setting can be doubled, there is a definite economic saving even though the initial cost of the better grade firebrick were more than double that of the cheaper brick.

Due to these changes in furnace conditions, a great amount of time has been spent in developing laboratory tests that would help indicate how firebrick would function in practice if the conditions as to type of fuel and design of furnace were known. These tests have been rather difficult to devise, due to the fact that firebrick are far from uniform, and have a very different texture. Even when brick are made from the same clay, molded in the same way and fired in the same kiln, there is frequently a large variation in some of the properties of the brick due to the non-uniformity of temperature in the kiln. For example, a brick burned at the top of a kiln in contact with the hottest gases is frequently fired at a higher temperature than a brick in the bottom of the kiln. If this increase in temperature is enough to vitrify the brick, one will find marked differences in the various properties of the brick. This variation between individual brick of the same brand has made the development of tests rather slow due to the difficulty in securing check results.

The first change in the matter of testing was to substitute a load test at high temperatures for the fusion test. It had been found in practice that the fusion point was often misleading as to the ability of a brick to stand temperature alone. Sometimes it was found that of two firebricks, A with a fusion point of 3100°F, and B with a fusion point of 3200°F, A kept its shape in the furnace wall while B had softened, and would not support the load imposed by the wall above. This was probably due to the fact that A had a sharper melting point than B, a fact that the fusion test did not indicate clearly. Clay firebrick do not have sharp melting points such as the pure metals, but gradually soften in the same way as glass. This softening range often extends over several hundred degrees, and of course when a brick softens to the extent that it will not carry the load of the wall above, it is useless although the temperature may be several hundred degrees below the fusion

SLAG TEST SPECIMEN
From Heat Measurements Laboratory. Shows pitting and absorption of slag.

point of the brick. The load test at high temperatures was devised to meet this trouble and consisted of heating a brick, stood on end, at a specified rate with a fixed load of 25 pounds per square inch. The amount of contraction of the brick was measured after the brick had been held at 2462°F for 1½-hours. The amount of this contraction gave an indication of the load carrying ability of the brick and was a far better means of determining the ability to withstand temperatures than the fusion test. Sometimes this test has been made, so that the temperature is increased at a specified rate and continued until the brick has contracted some definite

(*Continued on page 88*)

Recent Books

This department conducted in co-operation with the Technology Library

Advanced Textile Design. By William Watson, Superintendent and Lecturer in Textile Manufacture, The Royal Technical College, Glasgow. 2nd Edition, 1925. Longmans, Green & Company.

The extended use of complicated designs and weaves in textiles during the last decade has called for a knowledge of double and triple fabrics and figure weaving of a highly specialized character. This noteworthy work is a rewriting of the author's standard work which first appeared in 1912. The book contains over 450 excellent illustrations and some 2,000 designs and diagrams representing woven fabrics. The author is a master of the art of weaving and sets forth in a thorough manner the design and production of double and treble cloths whereby a double and triple set of warp and filling threads are wrought into fabrics with desired effects upon the face and reverse sides. The principle of double and triple weaving has been extended during the last few years so as to take the place of separate linings and waddings in garments, the same being now woven as one composite fabric. In this manner overcoating, for instance, can be woven together with its lining in such a manner as to present a wholly different appearance upon the face and reverse sides. The extension of this principle is practically limitless and the author takes up many special cases of figure weaving and wadding in double and triple cloths. The subject of extra figuring in warp and filling forms a very complete chapter. The Jacquard loom with its unlimited possibilities in figure weaving is handled at very great length. In the last portion of the book are several chapters upon gauze and leno fabrics as produced by the Jacquard loom. In extreme contrast to this, heavy pile fabrics, such as velvets, plushes and velveteens are illustrated by many diagrams and illustrations.

Such a book as this represents an immense amount of study and forethought with a high degree of specialized skill on the part of the author. It is a book abundantly worth studying and the value of it can only be appreciated by extended perusal. It should be upon the shelves of every textile plant and laboratory where complicated cloth formations are liable to be encountered.

GEO. B. HAVEN, '94.

Crystals and the Fine Structure of Matter. By Friedrich Rinne, Professor of Mineralogy in the University of Leipzig. Translated by W. S. Stiles. New York: E. P. Dutton & Co., 1924. 195 p. illus.

The practice of dedicating scientific books to the general public grows daily in popularity; too often, however, a book is written for the scientific world, and then is offered, apparently as an afterthought, to the student and the general public. Professor Rinne's book on crystals is of this class. In his first chapters, those on the structure of crystal forms, he presupposes considerable knowledge of the subject on the part of the reader, touches lightly on the fundamentals of the science, and often passes by a complicated diagram with no more than a word or two of explanation The result, in the mind of the beginner, is confusion rather than illumination.

The book takes up the structure of crystals, and some of the methods of investigation; the relation of crystals to atomic and molecular form; the extension of the ideas on crystal structure to gases and liquids; the arrangements of the particles in mixed crystals, etc.; crystal growth and solution, and the course of chemical action on crystals.

In the chapters on chemical reactions, Prof. Rinne presents some interesting and, I think, novel ideas.

The book is well bound and profusely illustrated, and should be of interest to those who are already equipped with a knowledge of crystallography; but its usefulness to beginners in the subject or to the general public is doubtful.

L. HARRIS.

BIOGRAPHY

Kelvin Centenary: Oration and Addresses Commemorative. London: Percy Lund Humphries, 1924.

William Thomson, Lorn Kelvin, was born June 26, 1824. One hundred years later, when engineers and scientists from all parts of the world were gathered in London for the first World Power Conference, the Royal Society of London sponsored the Centenary celebration of the event. There was an exhibition of Kelvin experimental apparatus, a banquet, and a general meeting. Sir J. J. Thomson gave the memorial address, and among the banquet speakers were Dr. Elihu Thomson and Dr. A. E. Kennelly.

The 100 pages of the commemorative volume cited above give an account of the Centenary proceedings, including Sir J. J. Thomson's Kelvin Oration, the banquet speeches, and 29 short addresses by the delegates of as many learned societies. To add a personal touch, the facsimile signatures of the delegates are affixed to the printed speeches.

CHEMICAL ENGINEERING

The Recovery of Gasoline from Natural Gas. By George A. Burrell. New York: Chemical Catalog Co., 1925. 600 p. (American Chemical Society. Monograph Series.)

Gasoline from natural gas, now called Natural Gasoline, had its beginning in 1903, and in 1924 constituted about seven per cent of the gasoline used in this country. There are about 1,200 plants manufacturing it, most of them using the compression method. This book traces the development of the industry, outlining its present theories and describing in detail present processes of extraction and distribution, as well as its other aspects.

CIVIL ENGINEERING

Traite de Stabilite du Materiel des Chemins de Fer. Influence des divers elements de la voie. By Georges Marie. Paris: Beranger, 1924. 579 p.

The author, a prominent French engineer, has for a quarter-century studied the problems of stability of railway rolling-stock (i.e., its resistance to derailment) arising from condition of rails and roadbed and the speed of trains. This work is a complete presentation of his studies and conclusions.

ELECTRICAL ENGINEERING

Electric Cables: Their Design, Manufacture and Use. By William A. Del Mar. New York: McGraw, 1924. 208 p. 58 fig.

This is not another edition of the author's early work on "Electric Power Conductors," but a wholly new book comprising a course of 15 lectures given by Mr. Del Mar in the capacity of practising engineer now connected with the University faculty at the Moore School of Electrical Engineering at the University of Pennsylvania during 1923-24.

The content of the volume, though presented in an informal manner, includes every phase of cable study—manufacture, testing, theory of operation, and application in special uses. Its up-to-dateness is evidenced by such a chapter head as "Present voltage limits," and by numerous tables of specifications and data used in current practice. Appendix 8 gives a "Summarized history of published knowledge bearing upon the performance of insulation under electric stress," its items covering the earliest historical references, as well as the most recent articles and being explained by a concise sentence or two after each reference. This bibliographic summary, originally compiled by a sub-committee of the American Institute of Electrical Engineers' Standards Committee, has been brought up to date by C. F. Hanson and the author, and offers a most valuable basis for further study.

METALLURGY

Molybdenum, Cerium, and Related Alloy Steels. By H. W. Gillett and E. L. Mack. New York: Chemical Catalog Co., 1925. 299 p. (American Chemical Society. Monograph Series.)

The authors, formerly alloy chemists with the U. S. Bureau of Mines, believe that molybdenum is destined to take its place beside nickel, chromium and vanadium as an alloying element. In order to obtain more complete information as to its endurance and impact properties, extensive experimental work was carried on in co-operation with various firms and at Sibley College, Cornell. The book records the results of these tests and draws most favorable conclusions therefrom. Cerium is dismissed as having no true alloying effect.

Here and There

Humorous notes from the Editor's desk.

THE LIFE OF AN ENGINEER'S WIFE

One day early in 1918, an engineer's bride was introduced in a western city to a British Y. W. C. A. worker whose husband was Major C—— of the Royal Engineers. The bride rather shyly told the visitor that the husband, who had sailed for France at the close of a brief honeymoon, was an engineer, too, though just beginning his career.

"I hope you have a roving foot," the Englishwoman laughed. "You'll need it if you hope to be happy. We have been married fifteen years and ten months of that time is all that we've spent at home in Surrey. But I've seen men battle and conquer nature in most of the wildernesses of the world. I've watched them conceive and achieve the impossible. Always I've felt myself a small part in vast enterprises. And I would not exchange that feeling for all of the roots in the world."

As they parted after tea, she said, "It's not 'good-by.' Some day we'll meet again at Melbourne or London, in the Himalayas or Andes, here in Washington or somewhere in Central Africa. For I think you're a rover, too."

Not for an engineer's wife are the stores of ancestral attics, the fragile perfection of antiques that have been treasured in the same house for generations, deep roots, permanent ties, plans that can be made with assurance of future accomplishment.

The Chelsea bowl that was the engineer's wife's most prized wedding gift has a nick that is a souvenir of the move-before-last. One handle of her great-grandmother's Wedgwood urn was battered off by a freight handler between Seattle and Boston last year. All her precious books have a packing box look, and her furniture wears an air of comfort without enough beauty to cause pangs at parting next year.

When friends at the tea table ask if she remembers the Branch scandal in 1915, she shakes her head. "We were in California that year," she reminds them, and then lets her thoughts wing their way across a continent to a construction camp and a little group of men, dwarfed beside the smooth white masonry of a great dam. Back in the power house a switch is pulled, the gates close, the water rises higher, higher, higher, until it goes pouring smoothly over the spillway. And once more engineers have forced Nature to bow to Man's will.

Those are the memories of an engineer's wife. Life may be lonely, but never dull. She may not hear an opera for years, but she knows the music of the firs in a storm. The thunder of a river on rampage has created a thrill that Wagner by a super-symphony could not stir. And clear skies with receding waters and trilling birds—not even Kreisler can rival that triumphant music.

She is forever saying good-by. But there are new faces for old, new ties for past ties, and here and there all through the world are the faithful friends of each new contract, one or two or a half dozen; so that her heart grows large reaching out and remembering those she loves from rising sun to rising sun.

Who is there of women unable to find thrill in the life of an engineer's wife?

N.B. I regret to say that this typewriter will never be the same instrument again. It received a lasting shock at the hands of the American Railway Express two-moves-before-last.—*Stone & Webster Journal.*

This page is an innovation from established policies. It is hoped that it will prove an interesting page to our readers. The page has been called "Here and There" for want of a better name, the idea being that on it will be published short articles taken from everywhere. It will be a place where the Editor can publish such excerpts, as he thinks interesting, on the engineering field. These excerpts will be taken from industrial magazines, trade journals, and the like. This page will be continued in issues to follow.

CAMELS VS. CHESTERFIELDS

There is never any smoking where Henry Ford signs the payroll. A certain Boston firm of engineers were doing a piece of work for him out in Minnesota. It was a big job, the total cost running up in the several millions, and this firm was retained on a cost plus or percentage basis. They furnished the engineering service and supervised the construction, Ford paid the bills, and they received a percentage of the total cost as their part. The local engineering and construction force soon found out that smoking was strictly prohibited any place within the bounds of the job during working hours. That was pathetic, especially if you were one of the force, but it was humorous to watch the big boys from the Boston Office when they came out. They had no more than lighted up than the Super came around and politely, but firmly, informed them that they would have to get off the job if they were going to smoke. They did, and to do so, they walked a half mile through a slimy wet passageway that led through the dam to the other side of the Mississippi River, thus proving the prophecy made years ago about "Walking a Mile for a Camel," but these were Chesterfields.

CONTRACTORS

Every contractor at some time during his career has been accused of pulling some crooked deal, especially if he is engaged in doing municipal or public work. But the world is evidently not growing any worse, for Kipling tells us the following little story about contractors on public works back in the days of the pyramids:

"Who can doubt the secret hid
Under Gizeh's pyramid
Was that the contractor did
Cheops out of several millions."

FROM WHENCE THE ENGINEER?

At last the why and whence came of the engineer is explained. We always wondered about this until the following was found in the *Engineering News-Record* some time back.

"Dr. Elliot Smith, professor of anatomy in the University of London, says that the first king of Egypt was an engineer. Dr. Smith, who was professor of anatomy in the government medical school at Cairo, and who unwrapped the mummies of thirty kings of the Pharaoh dynasty, told a reporter of the Cleveland *Leader* that agriculture and embalming were the two sciences that laid the foundation for European culture.

"The valley of the Nile was fertile, but as population increased a famine threatened unless some means could be found to increase the yield of barley," he said. "The first engineer was the man who learned how to irrigate, about 4,000 B. C., so the Nile could be made to produce two or three crops of barley a year instead of one that had been watered by the overflow of the stream. This engineer became the king. Early pictures represent the king holding a hoe. Thus the king became the custodian of the food supply and it was in the hope of continuing the benefits he conferred that embalming was used to keep him alive."

The later kings must have gone back, if we are to believe Kipling's verse.

Professional Notes

Activities of the Undergraduate Engineering Societies at the Massachusetts Institute of Technology.

ELECTRICAL ENGINEERING SOCIETY

At a smoker on March 27, Mr. Farley Osgood, president of the American Institute of Electrical Engineers, spoke before the Society. His subject was "What the College Graduate runs up against and how to meet it." Among other things, he advised against buying a car too soon after graduation; but the piece of advice which, judging from its reception, was the most popular with those present, was Mr. Osgood's advice not to get married too soon. His reasons were that by doing either of these things the fellow was tied down to his job to support either his car or a wife and could not shift from one job to another to find the one which was best suited to him, because the first is merely an experiment on the part of the graduate.

Another smoker was held during the first part of April, at which Mr. Davis, '03, spoke. The subject of his talk was the future of the electrical industry. He painted very rosy pictures for the future and ventured the statement that many then listening to him would take part in advancing the science as far beyond the present stage of development as the present is advanced over the crude first beginnings of thirty or forty years ago.

CIVIL ENGINEERING SOCIETY

On the 27th of March, A. A. Shurtleff, '94, a practicing landscape architect, spoke to the Society on the subject of "Town and City Planning." Mr. Shurtleff is a member of the Metropolitan Planning Division for Massachusetts on Town Planning and Highway Transportation in an advisory capacity and he is also advisor to many of the towns and cities around Boston.

The speaker outlined the lay-out of a town or real estate development from the blue-print to the actual building construction. Furthermore, he showed the difference between a good and bad lay-out, illustrating his points by graphic descriptions and lantern slides.

At the next smoker, on April 9, Professor Breed spoke to the Society on the subject, "The Engineer as an Expert Witness." The speaker gave those present an idea of the kind of facts that an engineer as an expert in his line would be expected to present in court, should he ever be called upon to do so. Professor Breed also emphasized the fact that the testimony should be unbiased and that the personal equation should be eliminated as far as possible.

CORPORATION XV

Recently the Corporation took two trips, one to the United Drug Company's plant in Boston, and the other to the Gillette Safety Razor Company's plant, also in the city.

At the United Drug the party saw the processes of manufacture of many of the patent medicines in large quantities. They followed the various chemicals through from the raw material to the finished product, and were also taken through the Pure Food department and saw the testing laboratory, where several varieties of canned foods are analyzed to see that there are no adulterants present in the product, which is to be sold in the markets to the public. Here also the patent medicines are tested after the processes of manufacture are completed. After this the party had the administrative side of the business explained to them.

A week or more later the Corporation took another trip to the Gillette plant. The Gillette Company makes one of the leading types of razor. Here, also, the party saw the process work involved in the manufacture of the product. The methods of testing the steel used in the blades was shown them.

MECHANICAL ENGINEERING SOCIETY

The Society held a meeting during the latter part of March, at which the subject of Electricity and the Automobile was presented. The whole subject was covered, the earlier developments being treated more from the historical viewpoint than the modern methods, which were discussed from the point of view of actual operation. The meeting was held by the Automotive Engineering Society, which is sponsored by the Mechanical Engineering Society. The theory of the operation of the various ignition systems used in each of the several makes of automobiles was explained and whenever possible slides were used to supplement the verbal explanation.

During the latter part of April, the Society took a very interesting trip to the Weymouth plant of the Edison Company. The party left the 'Stute in buses, chartered for the occasion. The inhabitants of the several towns through which the party passed were left speechless by the greetings of "those college boys." Arriving at the plant the party was divided into smaller groups, each of which was assigned a guide to take them through the station. The guides told those whom they were taking through many of the interesting incidents incident to the construction. Also, in several instances the particular function of a given piece of apparatus was explained in detail, wherever in the guide's opinion, the use of that particular thing was to a certain extent unusual or improved the economy of operation of the plant. The party returned to Boston in the buses and gave the people enroute a chance to observe and censure "those college boys."

MINING ENGINEERING SOCIETY

During the latter part of March the Society was fortunate enough to secure Mr. Rogers, a mining engineer of international repute. His talk was more on personal reminiscences of his own experiences rather than any technical details of any given job or kind of job. He described mining as it is practiced in Central and Northern South America, and digressed from his theme to describe with varying amounts of detail and personal reminiscences the life in Central America. Not only did he describe life in mining camps, but he also described the everyday life in the cities and towns as well as on plantations.

Furthermore, he briefly outlined the geography of the Central American countries. He told his listeners of the attitude of the natives to the foreigner in general, and in particular, their attitude toward Americans or persons representing American business houses. Then he gave his listeners an opportunity to ask questions and spent nearly as much time answering questions as he had in delivering his original talk. As a result, those who heard him got a very good idea of the chances for success, with which a mining engineer would meet in Central or South America, for Mr. Rogers said that anything he had said as regards generalities would apply equally well in any of the Spanish-speaking tropical countries.

The Engineering Field

Excerpts from the leading professional and trade journals.

High Power Aviation Units. Packard has at last announced the new high-power, twin-six aviation engine, meagre reports of which, as in process of development, have during the past few months been heard.

With the large motor is announced a smaller one of 500 horsepower, developed by 1,500 cu. inches, at a speed of 2,000 r.p.m., which weighs only 730 pounds. It evidently is intended to be successor to the Liberty motor of only 400 horsepower and weighing 840 pounds. The new motor enjoys other than weight and power advantages over the Liberty, being smaller, occupying less space in the fuselage and having less head-on area.

The large motor develops 800 horsepower, having a capacity of 2,500 cubic inches and designed speed of 2,000 r.p.m. It weighs 1,072 pounds, which makes it the lightest motor yet developed—1.34 pounds per horsepower—well on the way toward the goal of a pound per horsepower. It is a "square" motor having a bore-stroke ratio of one. Splendid design has reduced the distance between cylinders to a minimum, keeping down the length and weight. A single camshaft is over each set of six cylinders, being driven from the pump end of the motor. There is a novel double magneto and clever distributor arrangement in the center of the 60°V, which saves half the usual magneto weight. The exhaust valves are cooled by a splendidly worked out system of oil flow through the hollow valve stem. The valve and camshaft mechanism are entirely enclosed Navy acceptance tests of sixty hours in both normal and inverted positions at full throttle have been passed successfully.

Bench Screw-Thread Comparator. A device known as a "Bench Screw-Thread Comparator" embodies a scheme which makes it possible to simultaneously and accurately compare the pitch, diameter, form and lead of production screws and taps with a standard master screw.

The equipment with which this is accomplished consists of cradles, in which the work is held for inspection, master gages, and tolerance charts, on which the shadows of the threads are projected for comparison. The fixed threaded cradle is spaced longitudinally from the center of the lens to a distance equal to the length of engagement of the screws being inspected. The second threaded cradle is free to move endwise to compensate for lead errors. The practical advantages of this instrument are: it is the fastest method of inspecting threads, it is the only method which compresses the thread tested with all elements of an accurate master gage, and it is the only method which eliminates the cost and uncertainty of gage wear.—*Scientific American.*

Smallest Marine Racing Engine. This little French (Anzani) engine, now being marketed in this country, was developed for use in small racing hydroplanes classed as having engines within one and one-half liters, or 63 cubic inches, capacity. It is of the necessary ruggedness for marine use, yet is very light, weighing 182 pounds complete, and is remarkably powerful for its 2 7/16-inch bore by 3 9/16-inch stroke, developing with supercharger 40 h.p. at the extremely high speed of 4,500 r.p.m.—*Rudder.*

© *Rudder*

SMALLEST MARINE RACING ENGINE

French (Anzani) engine developed for use in small racing hydroplanes.

New Studies On Airplane Dusting of Cotton. In the studies that the Bureau of Entomology has been making on boll-weevil control by means of airplane dusting, much attention has been given to the mechanical features, and numerous devices for distributing the poison from the plane have been developed and perfected. Different types of planes require quite different equipment. Special planes are also being developed and extensive plans are under way for more widespread use of this method.

The airplane dusting has led to many interesting and important developments, such as the possibility of dusting by daylight. Heretofore, the poison has been applied at night when moisture on the plant caused the dust to adhere. It has been found that by charging the dust with electricity of a polarity opposite to that of the plant, the dust as it settles over the field is attracted and adheres to the plant, covering its leaf and stem surfaces completely. An extensive cooperative project is under way, with the Bureau of Public Roads on the mechanical side, and the Bureau of Standards on the electrical side, thoroughly to work out the principles involved and their possible commercial application.

A thorough study has been made of the different types of calcium arsenate in relation to their effectiveness for weevil control. This is being correlated with methods of manufacture and several new methods have been studied. It is hoped that when the study is complete a much more efficient calcium arsenate will be available, and furthermore, that it will be possible to eliminate materials of low efficiency which have been responsible for erratic results by the farmers in the past.—*Industrial and Engineering Chemistry.*

Replacing Old Rails. An interesting account of a method of procedure whereby the old tracks of railroads in Alabama are replaced by new ones without tying up traffic is given by the Metal and Thermit Corporation in the *Electric Railway Journal* and is as follows:

"The new rails are aligned on temporary ties alongside the track in lengths varying from 2,000 to 4,000 feet. They are then welded, and the welds are ground, after which they are "snaked" into position next to the old running rails and spiked down to gauge. This done, it then is a simple matter to divert traffic from the old running rails to the new; not more than five minutes being required for this operation."

Trench Excavating. Engineers have recently developed a new and successful method of obviating the usual expensive bracing and pumping where pipe trenches must be dug in wet sandy ground — even where ground water is within a foot of the surface. On a job of this kind well points were driven to one side of the trench line, spaced about six feet apart and carried slightly below the proposed trench bottom. Pipes placed in them were connected with rubber hose to a 4-inch surface pipe. A 7-inch by 10-inch motor-driven triplex pump connected to the surface pipe kept the trench perfectly dry for a distance of 400 feet at a time.—*Factory Mutual Record.*

Internal Combustion Boiler. A Belgian engineer, Oscar Brunler, reports that he has succeeded in developing a boiler capable of working over long periods of time without shutdown, in which the flame burns in direct contact with the water. The apparatus consists of a large boiler reservoir with a small burner in the steam space for superheating purposes, one or more small bowl "generators," which comprise water container, immersed burner and regulating valves; and an air compressor. The water is drained from the generator, the burner ignited and controlled by a valve which automatically keeps a constant ratio between the oil and the air, while regulating the size of the flame. Then the water is allowed to rise and cover the flame, which burns quietly under the surface. The temperature of the flame is approximately 3,300 degrees F. Steam produced passes from the top of the generator to the reservoir space. The necessity of compressing to more than full boiler pressure all the combustion air required seems to be a serious drawback. On the other hand, flue losses are evidently eliminated, which would lead one to expect a very high boiler efficiency. This expectation is not disappointed; in fact, Mr. Brunler insists that the efficiency obtained, based on the best reliable calorimetric measurements, runs continuously over one hundred percent. This claim will undoubtedly be greeted with skepticism, which will not be decreased by Mr. Brunler's suggestion that some unknown electrical forces may exist to make up the difference between the heat he obtained in the generator, and what he supposed to be in the oil. It is dangerous to make fun of any idea these days, but Mr. Brunler should not be surprised if engineers demand further proof of his efficiency claims.—*Power.*

The longest commercial air route in the world via hydroplane is in regular operation in South America. This will surprise most laymen. Some 600 miles in length, it links the Columbian seaport of Barranquilla with the national capital of Bogota. Until the coming of the aircraft this journey by boat, train and pack mule required from ten days to two weeks. Now it is accomplished twice weekly in less than two days with the regularity and dependability of an express train service.

The aircraft operating on this route recently performed a unique service. A bank had failed in Bogota, and a serious run was threatened on all other banks in the capital. To avoid this catastrophe the government declared a fiesta of three days, during which business was suspended. This made it possible to rush bank notes and securities from the coast to relieve the situation while the bank remained legally closed. Two hydroplanes took the air on that particular day, the Bogota and the Cauca. The first took no passengers but carried gold certificates worth $1,500,000.—*Aero Digest.*

Final Road Tests of Gas-Electric Bus. Final road tests on the first of 200 gas-electric buses for the Philadelphia Rural Transit Company have been completed at the plant of the Yellow Coach Manufacturing Company in Chicago. The power unit consists of a six-cylinder 4¼″ x 5½″ sleeve valve engine, developing 108 h.p. at 2,200 r.p.m. driving through a propeller shaft and new type of rubber ball universal joint a 25-k.w. generator. At idling speeds of the engine the voltage generated is so low that only a negligible flow of current takes place through the motor. It is therefore possible to have the generators and motors connected at all times. Under this condition the controller handle is in the forward position, and the bus is started and accelerated simply by opening the engine throttle. Due to the differential winding of the generator, the electrical characteristics are such that as the load required by the motor decreases as balancing speed is approached, the voltage rises. This increased voltage, together with the decreased torque requirement, still further increases the speed of the motors. Since the rate of acceleration of the bus is predetermined, regardless of how suddenly the throttle is opened, the engine cannot be stalled during the process of acceleration.

The tests indicate a fuel consumption below that of a gear-driven bus of the same size and type and very satisfactory powers of acceleration.—*Electric Railway Journal.*

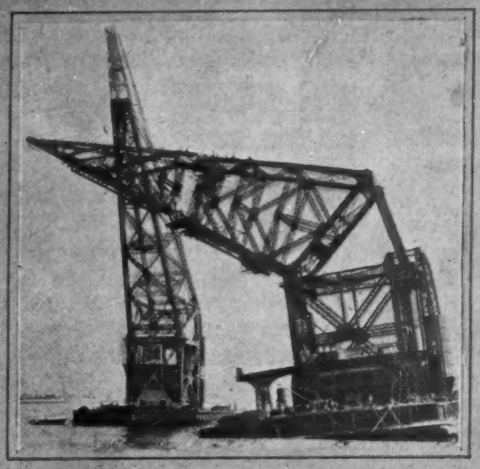
A New Electric Locomotive. One of the main obstacles in the way of complete electrification of railroads has been the wide difference in the requirements for transmission of electric current and for its best use. Electricity is most economically transmitted as alternating current of high voltage. It can be most efficiently and economically used as direct current at low voltage. Until the present time, electromotive engineering has had to be content with compromises. Less economical types of motors have had to be used, and railroads have had to maintain costly "step-down" transformer stations along the right of way.

Electric locomotives of a new type that carry their own transformer stations and "step-down" a high-voltage alternating current to a low-voltage direct current, are being installed on the New York, New Haven and Hartford Railroad. The new locomotives carry their own transformers with them, and change 11,000-volt alternating current, which they take directly from the trolley wire to lower-voltage direct current, which is fed to their motors. Six of the new type of electric locomotives have been built by the General Electric Company for this railroad, and are being given a thorough test under working conditions. —*Daily Science News Bulletin.*

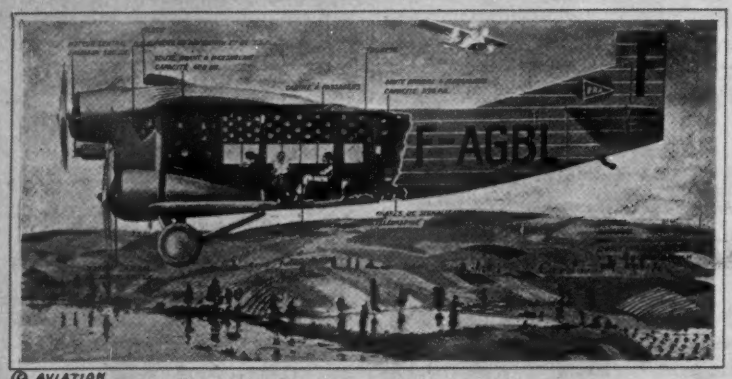
Crystallized Copper. Dr. W. P. Davey, research physicist of the General Electric Company, has produced copper crystals, one inch in diameter and six inches long, whose electrical conductivity is 113 per cent that of ordinary pure electrolytic copper. These relatively large crystals were produced by heating copper very slowly in an electric furnace and then cooling it again equally slowly. The prepared copper could be bent without effort, but once bent could not be straightened out again. This is attributed to the effect produced by bending in upsetting the balance of the atoms of the copper; the crystal readjusting itself into smaller crystals again, so that for all practical purposes, it becomes a bar of ordinary copper and is equally inflexible.— *Mechanical World.*

Steam Turbines. An innovation in the application of steam turbines to ship propulsion is embodied in the employment of geared turbines to drive the side paddle-wheels of a Rhine tug. A year of operation is said to have shown marked economy in coal consumption over the ordinary reciprocating plant in general use.—*Engineering London.*

Crank Case Oil Tester. An oil tester for garage service which does away with the customary thermometer and stop-watch has recently been put on the market. In principle it is very simple, a sample of the oil to be tested is enclosed in a glass tube and mounted on a frame beside a tube of the same inside diameter, which contains oil of standard quality. Room is provided in each tube for an air bubble. The oil is tested by comparing the relative speeds with which the two air bubbles rise when the frame is inverted. If the bubble in the used sample reaches the top of its tube before that in the standard tube, indicating too great dilution or loss of viscosity, the oil is rejected.



TOP SECTION OF LARGEST U.S. NAVY FLOATING CRANE BEING PUT INTO PLACE BY THE SECOND LARGEST OF THE FLOATING CRANES OF THE NAVY.



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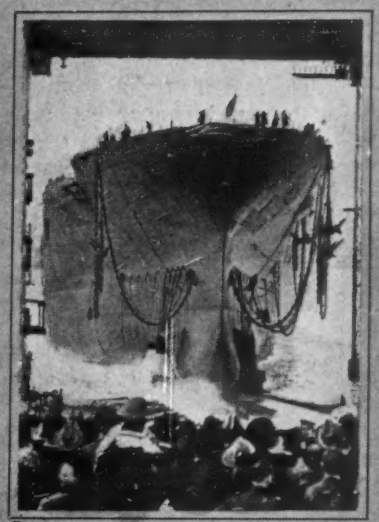
SCHEMATIC CROSS SECTION DRAWING OF FARMAN JABIRU PLANE POWERED WITH 3-300 H.P. SALMSON MOTORS. THE PLANE IS ON THE PARIS-VIENNA RUN OF INTERNATIONAL AIR LINES OF PARIS.



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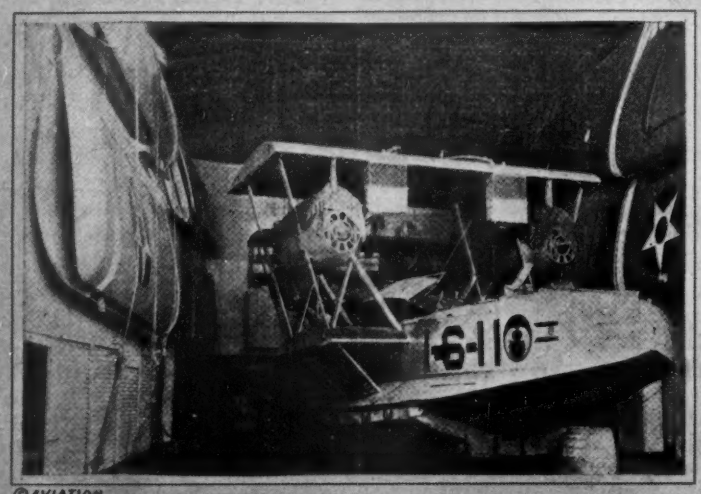
LAUNCHING OF U.S.S. SARATOGA, THE LARGEST OF AEROPLANE CARRIERS. ITS COST IS 45 MILLION DOLLARS.



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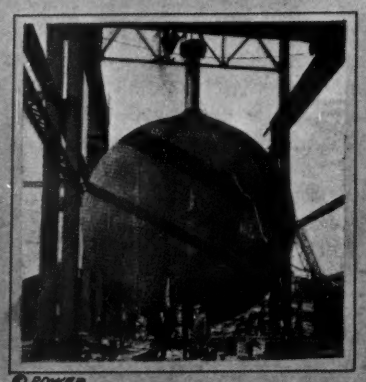
P.N. 7. (WRIGHT TORNADO) SCOUTING PLANE IN THE HOLD OF THE U.S.S. WRIGHT ON THE WAY TO HAWAII.

THIS BUTTERFLY VALVE IS 26.5 FT IN DIAMETER AND RESISTS A THRUST OF 1,855,000 POUNDS.



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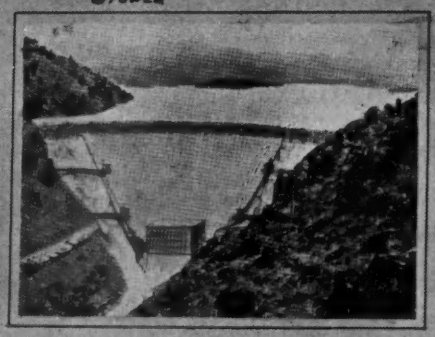
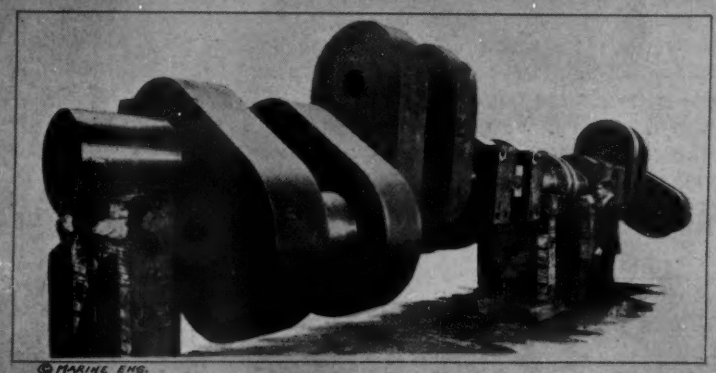
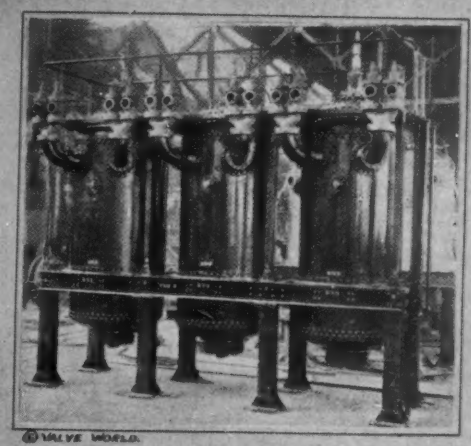
FIRST WATER OVER SPILLWAY OF THE WILSON DAM. THE DAM IS THE LARGEST SINGLE PIECE OF CONCRETE IN THE WORLD. THE LEVEL OF THE RIVER HAS BEEN RAISED 93 FT AND A LAKE 18 MILES LONG, HAVING AN AVERAGE WIDTH OF 3/4 OF A MILE, WAS FORMED BY THE DAM.



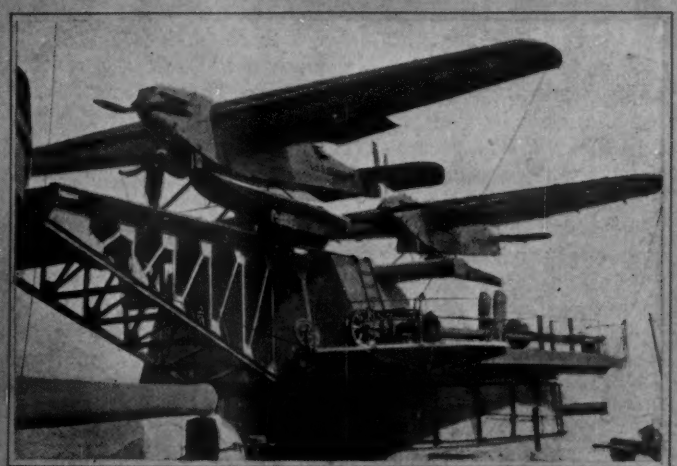
ARTIST'S DRAWING OF EXCHEQUER DAM IN SAN JOAQUIN VALLEY. IT WILL BE 310 FT. HIGH AND THE PLANT WILL HAVE A CAPACITY OF 30,000 KW.



© MARINE ENG.
67 TON CRANKSHAFT OF 8150 H.P. BURMEISTER AND WAIN DOUBLE ACTING MARINE ENGINE INSTALLED IN TRANSATLANTIC LINER.



© VALVE WORLD.
A BATTERY OF ELECTRIC STEAM GENERATORS BEING INSTALLED IN A QUEBEC PLANT. CHEAPER ELECTRICITY IS CAUSING AN INCREASED USE OF THIS TYPE OF STEAM GENERATOR.



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AEROPLANE CATAPAULT ON THE U.S.S. MISSISSIPPI.

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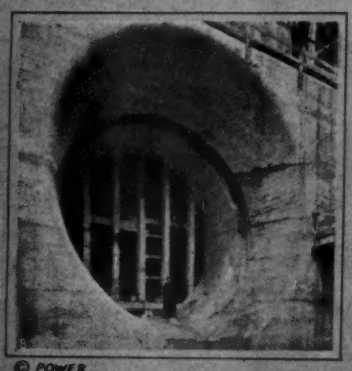
NEW DEEP SEA DIVING SUIT BY WHICH A DEPTH OF 525ft HAS BEEN REACHED.



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BUTTERFLY VALVE HOUSING IN PENNSTOCK OF THE EXTENSION TO NIAGRA FALLS POWER CO.

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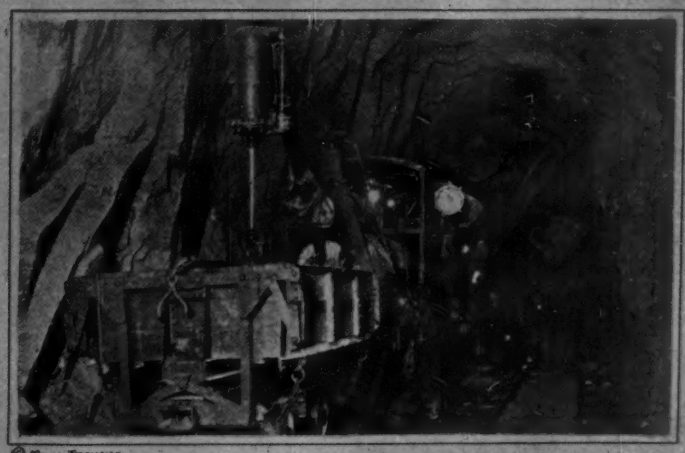
LATEST TYPE U.S. ARMY TANK COMBINED HIGH SPEED AND HEAVY ARMAMANT.



© MECH. TECHNIC.
A MECHANICAL MUCKER AT WORK IN THE MOFFAT TUNNEL. THE AIR CYLINDER IN THE REAR ELIMINATES SWITCHING BY LIFTING THE CARS FROM ONE TRACK TO THE OTHER.

Editorials

A GREAT OPPORTUNITY FOR THE ENGINEER

So many hours of mathematics. So many hours of physics. A language? By all means; English and History too. Not so much theory. Too much practical work. . . . . And out of the cloud of battle the schedule of the would-be engineer takes form.

One educator, bolder than the rest, suggests psychology. But does it need an "ology" to show the student that among the most valued knowledge of the engineer should be the knowledge of men? Stringing wire for a telephone company, perhaps, installing machinery in some out of the way part of the world, in construction or mining camp, the newly graduated technical man finds himself directing other men who watch him critically and perhaps, at first, a little suspiciously. Critically to see if he "knows his job," suspiciously sometimes because to many of them he is the emissary of "capital." After all, a great part of the distrust in which so many labor troubles have their origin arises from lack of mutual knowledge on the part of the contending interests. It's much more easy for workers to rail against a "soulless capitalist grinding down his wages slaves" when he is pictured in a luxurious office many miles away than against his representative who may be joining them in common cause against a lazy cook. Just as it is a simpler matter for a certain type of executive to speak of "the iniquitous demands of men who are out for the overthrow of civilization," in the peaceful surroundings of a country club, than for the engineer in his employ to harbor the same feelings towards some of those very men who may happen at the same moment to be trudging miles through bad weather to bring help to him.

Fortunately, extreme bad feeling is not so very common but it does exist and elsewhere there are forever misunderstandings to be cleared up. To the engineer in very many cases comes first the sense of dissatisfaction abroad and to him also the first realization of the smooth-running progress that indicates general contentment. Often on his shoulders is thrown the burden of putting into effect unpopular orders, orders which he himself, perhaps, realizes to be unjust and must protest against. Or again, he may be called upon to show to excited men just where their demands are unreasonable.

Some men have the attributes which earn the respect and confidence of all with whom they come in contact, without any effort on their part, but the rest of us may help ourselves a little if we make use of the opportunities around us during a college course. To begin with, there is vacation work, and this is probably the most valuable of all. But we can do much during term time also, for men are much the same whatever work they happen to be doing and a student who has not the confidence, and in some small measure the respect of his classmates will not have any great influence over the men who work for him outside.

MORE FREQUENT GRADUATIONS

In a recent communication, the supervisor of employment of a great industrial organization makes a strong case against the present system of releasing almost all the year's graduates from colleges and technical schools in one large group at the beginning of the summer. From the point of view of industry in general, the arguments in favor of more frequent graduations appear almost unanswerable. Unquestionably it would be a more simple matter to absorb individuals or small groups into the different parts of the majority of organizations at comparatively short intervals. As each vacancy came in prospect the most suitable man already free or about to graduate could be informed and so find his work with as short a delay as possible to himself. Any extra burden thrown on others in the department in which the vacancy occurred, would be for a short time only. Finally, a far greater measure of individual attention could be given the newcomer at the time when it would be of the greatest value to all concerned.

A course offering such manifest advantages to industry in general obviously calls for investigation. Let us consider the other two factors in the problem, the educational institution and the much-discussed graduate himself. To consider the former first.

Students might be entered twice a year and their studies continued on this basis throughout their entire course. An alternative would be to carry out the present system for the first three years and make special arrangements for half the senior year to finish their college work in December by working throughout their last summer and in other ways making up the necessary time.

And what of the student? The writer of the communication, to which reference already has been made, states that the desire to help those undergraduates seeking temporary employment during the summer vacation is an added cause of difficulty. He himself suggests, however, that the present system is probably the most satisfactory as far as these men are concerned. The prospect of a large number of students hunting for temporary jobs in mid-winter in company with hundreds of the less fortunate of the nation's workers would appeal to labor as little as it would the students themselves. Those who do not work during the vacation would be largely free to choose their own time, but it is doubtful if many would choose to spend three summers studying. We may assume with some safety, then, that arguments from all three sides of the question point to the advisability of maintaining the present system for the first three years of the course.

The main object of the bulk of students is to have waiting for them on graduation work of a nature best suited to their necessities, qualities and ambition. Under the present system, a fortunate number enter at once upon their chosen work. Another group join the organizations of their choice in some temporary capacity—until such time as a permanent position is available. Many others, however, must be content to wait or, if necessity presses, seek unsuitable or uncongenial employment. If a man can afford to wait, he loses little and may put the intervening time to good advantage, while industry suffers not at all. But there are many who are not so fortunate. If the nation as a whole is considered, this group must form a large percentage of the total number graduating. If a temporary job can be obtained and the man meanwhile steadily pursues his search for more suitable and permanent work, he will probably not do worse than lose a certain amount of seniority. But too many may be inclined, perhaps pardonably, to relax a little after graduation and much good material may be diverted from the channels to which it is best suited or worse still, hopes may be blighted and stagnation follow. To avoid this danger, if clearly foreseen, men would make great sacrifices but granting our premise of the existing system for the first three years, the only way of meeting the situation without the loss of several months' time would seem to be the undertaking of some fifteen or more months of almost unbroken study. Some men are doing this, but it puts a severe strain on both health and finances and it is doubtful whether it could ever be more than a voluntary arrangement to meet a pressing need. College authorities would be unlikely to recommend its general adoption.

But the whole team doesn't play first base

To suppose that a baseball nine will all cover just one position is as far from the truth as to think that everyone in the electrical industry is an engineer.

This field will always need trained engineers. But with its great manufacturing, construction and commercial activities, the industry must have non-technical men too.

Since the industry is manned by many types, the result of your work will depend a good deal on the success with which you team up. The qualities that win are not only efficiency attained by the light of a study lamp, but that all-pull-together spirit of the athletic field.

This point of view may be useful to the man who has wondered whether campus activities, with all their striving and stern testing, their setbacks and their triumphs, have any counterpart in after life.

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Number 49 of a series

The Mercury Vapor-Steam Cycle

(*Continued from page 51*)

bine mechanical efficiency decreases with increase in pressure. With present design of steam turbines, the economic limit in pressure with the Rankine cycle is between 400 and 500 lbs.

This economic limit in pressure can be increased by reheating the steam so as to increase the quality of the steam in the latter stages of the expansion. This is represented by the diagram in Fig. 2 and shows steam under an initial pressure of 1200 lbs. and superheated to a total temperature

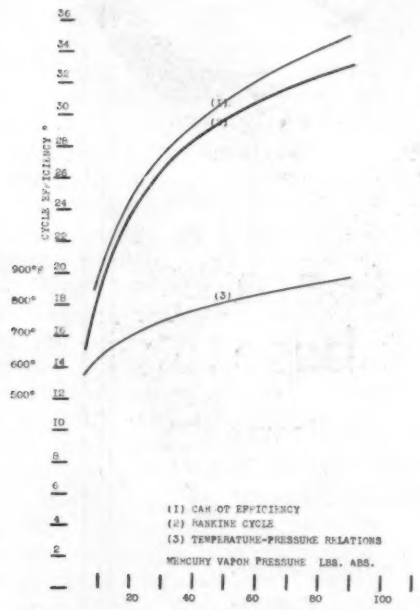

Figure 4

of 700°F, and then expanded adiabatically to 350 lbs. at which point it is passed back to the boiler and superheated at this pressure to a total temperature of 700°F again, and from this point expanded to the back pressure in the condenser.

However, reheating while it increases the turbine mechanical efficiency gives very little gain in cycle efficiency. Curve 2 in Fig. 6 gives efficiencies against initial steam pressures for a reheat cycle in which the steam is reheated at that pressure which will give the greatest efficiency. This obtains at a reheat pressure equal to practically 0.3 of the original pressure, being slightly greater at higher pressures. It may be observed from this curve that this merely gives an increase in efficiency of roughly 1 per cent in cycle efficiency throughout the whole range in pressures.

Thus, in general, it may be said that superheating gives very little gain in theoretical efficiency and the economic reason for superheating is the gain in turbine mechanical efficiency which it occasions. This shows that the simple Rankine cycle promises very little in the way of increased efficiencies, either by a very great increase in pressure or by re-superheating.

The type of steam cycle which will give materially greater economy than the simple Rankine, or reheat cycle, is the regenerative Rankine cycle. That is, in this case steam is bled from the turbine in order to heat the feed water and therefore is, in a sense, regenerative. The temperature entropy diagram in this case is shown in Fig. 1. The effect of bleeding the steam will be to reduce the available energy per lb. of steam, but the latent heat in this extracted steam is available to heat the feed water and therefore returned to the system instead of being transmitted to the circulating water. This may be conveniently shown by Fig. 1. Thus, with a plain Rankine cycle, the energy available is 36.5 per cent and the loss in the circulating water 63.5 per cent. With a regenerative Rankine cycle, it may be noted that the loss in available energy is 2.6 per cent, but that this loss makes possible returning to the system 17.7 per cent. The efficiency of the regenerative Rankine cycle is 40.6 per cent.

The possibilities of such a cycle are shown by Curve 4 in Fig. 6 This curve shows the efficiencies for various steam pressures and the steam superheated to a total temperature of 700°F. The efficiency varies from 36.3 per cent at 200 lbs. to 47.8 per cent at 1200 lbs. It may be noted that the regeneration is in all cases carried to that temperature which represents the

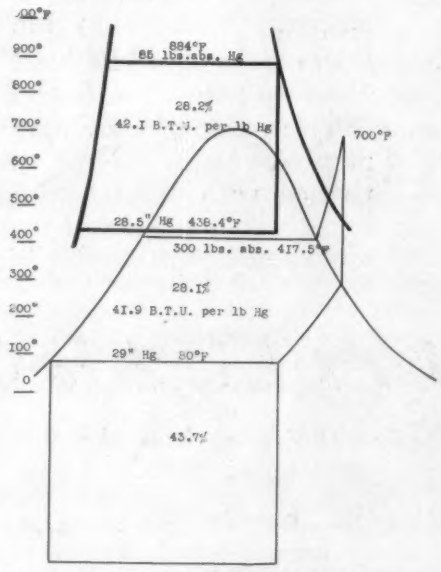

Figure 5

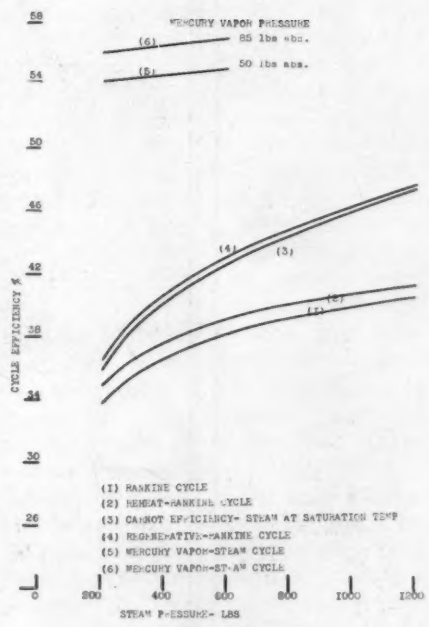

Figure 6

steam reaching the saturated condition in the turbine. This is due to the fact that the physical values in the case of steam are such that very little would be gained economically by regenerating further.

It may also be pointed out in connection with this cycle that if the steam were not superheated, the regeneration could be carried to the temperature corresponding to that of saturated steam at the initial pressure. This cycle would then give the efficiency of a Carnot cycle working between the same temperature limits. The Carnot efficiency corresponding to various pressures is given by Curve 3 in Fig. 6. This represents the maximum efficiency obtainable working between the temperature limits of steam at temperatures corresponding to saturation at the initial pressure and 80°F, or 29″ of vacuum. Curve 4 gives slightly higher efficiencies than Curve 3, due to the fact that the steam giving the conditions of Curve 4 is superheated to 700°F.

Diagrams showing regenerative Rankine cycles for 300 lbs. and 1200 lbs. are shown in Fig. 3.

The curves for steam cycles in Fig. 6 show that the efficiencies obtainable are not materially increased by going to high pressures. The actual efficiencies would be much less at the higher pressures due to excessive amounts of moisture in the turbine so that reheating would have to be resorted to, and this would limit the temperature to which regeneration is carried. In addition, in these calcula-

(*Continued on page 70*)

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GAS FOR INDUSTRIAL HEAT

The Mercury Vapor-Steam Cycle

(*Continued from page 68*)

tions an infinite number of heaters is assumed and in practice it would be limited to 3 or 4. Also the great density of steam at the high pressures and its resulting eroding effect would seem to limit the desirable steam pressure. The increased efficiencies available would have to be balanced against the increased capital charges resulting from increased pressures, and therefore set an economic limit to the pressure.

The Mercury Cycle

The mercury cycle is shown in temperature entropy co-ordinates by the heavy lines in Fig. 5. The initial mercury pressure in this case is 85 lbs. abs. and a temperature of 884°F expanding adiabatically to 28.5″ vacuum.

The theoretical possibilities of the mercury cycle is shown by Curves 1 and 2 in Fig. 4. Curve 2 gives the Rankine cycle efficiency for various initial mercury pressures expanded to 29″ vacuum. It may be noted that relatively small pressures give high efficiencies. Curve 1 gives the Carnot cycle efficiency for a cycle between the temperature limits represented by the temperature of saturated mercury vapor at the various pressures and the temperature corresponding to 29″ vacuum which is 414.0°F. The difference between the Rankine cycle efficiency and the Carnot efficiency is very small and is due to the water line in the temperature entropy diagram being nearly vertical.

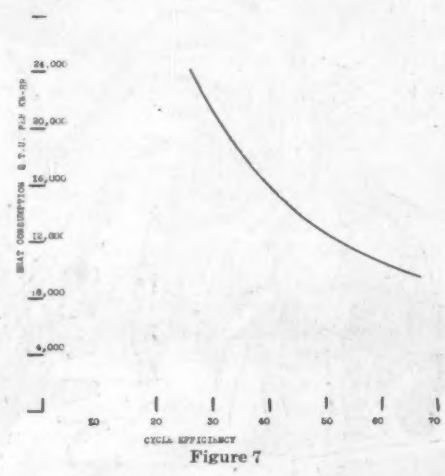

Figure 7

It may be observed that the water line is more nearly vertical in the case of mercury than with steam, and consequently the Rankine cycle efficiency of mercury will more nearly approach the Carnot efficiency than in the case of steam. In other words, the heat of the liquid at any given pressure expressed as a percentage of the total heat is lower for mercury than for steam.

The temperature of saturated mercury vapor for various pressures is shown by Curve 3 in Fig. 4.

The Mercury Vapor-Steam Cycle

The diagram of a mercury-vapor-steam cycle is shown to temperature entropy co-ordinates in Fig. 5. This diagram represents the condition for 1 lb. of water and 10.4 lbs. of mercury.

The initial mercury vapor pressure is 85 lbs. abs. and is expanded from this pressure adiabatically to 28.5″ vacuum. The temperature of the mercury vapor at this back pressure is 438°F, and allowing a 20°F drop in temperature in the condenser-boiler is convenient for the generation of steam at 300 lbs. abs. pressure. The steam at this pressure is then superheated to a total temperature of 700°F and

(*Continued on page 72*)

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Mercury Cycle

(*Continued from page* 70)

from this condition is expanded adiabatically in the steam turbine to saturation, and thence regenerating to 29″ vacuum in the condenser for the steam turbine.

The relative efficiencies of each cycle are 28.2 per cent for the mercury and 28.1 per cent for the steam, giving a total efficiency of 56.3 per cent, and a loss in the circulating water for the steam of 43.7 per cent. In terms of heat energy available per lb. of mercury, the heat energy available from each cycle is 42.1 B.T.U.'s for mercury and 41.9 B.T.U.'s for the steam. That is with mercury vapor and steam pressures assumed both turbines would have approximately equal ratings.

The efficiency of the mercury vapor-steam cycle for various mercury vapor and steam pressures is given in Fig. 6 by Curves 5 and 6. These curves give the efficiency of the mercury vapor-steam cycle for steam pressures, varying from 200 lbs. to 600 lbs., with the steam cycle identical to that giving efficiencies as given by Curve 4. The steam pressures may be varied by changing the mercury back pressure. With a back pressure of 29″ vacuum in the mercury condenser, the corresponding steam pressure of 230 lbs., and a pressure of 600 lbs. in the steam cycle, necessitates a mercury back pressure of 2 lbs. absolute.

The curves show that the overall cycle efficiency increases with increasing mercury turbine back pressure and corresponding increase in steam pressure. This is due to the fact that increasing steam pressures permit higher regeneration temperatures, and therefore materially higher steam cycle efficiencies whereas the mercury cycle approximates the Carnot cycle efficiency independent of the temperature limits.

The efficiencies obtainable approximate 57 per cent with relatively low mercury vapor and steam pressures and show large increases over that available from steam alone. This increase is of the order of nearly 50 per cent.

These efficiencies are obtained with very low mercury vapor pressures and higher mercury vapor pressures are both practical and possible and, therefore, would give materially higher efficiencies than those indicated

The most economical steam pressure would probably be a moderate pressure between 300 lbs. and 400 lbs. since present steam turbines have been more or less standardized at these pressures and it would permit operation of present steam stations by the addition of the mercury cycle.

The manner in which the cycle efficiency affects the heat consumption is shown approximately in Fig. 7. This curve shows for various cycle efficiencies the heat requirements in B.T.U.'s per Kw-hr.

These calculations assume a station efficiency of 55 per cent obtained as follows:

generator efficiency	97%
turbine "	78%
boiler "	80%
auxiliaries and misc.	91%

The curve shows that the heat required in B.T.U.'s per Kw-hr. for a mercury vapor-steam cycle with an initial mercury vapor pressure of 85 lbs. is of the order of 10,000 B.T.U.'s per Kw-hr. as compared with 16,000 to 18,000 B.T.U.'s per Kw-hr. required by a steam station under similar moderate steam pressures.

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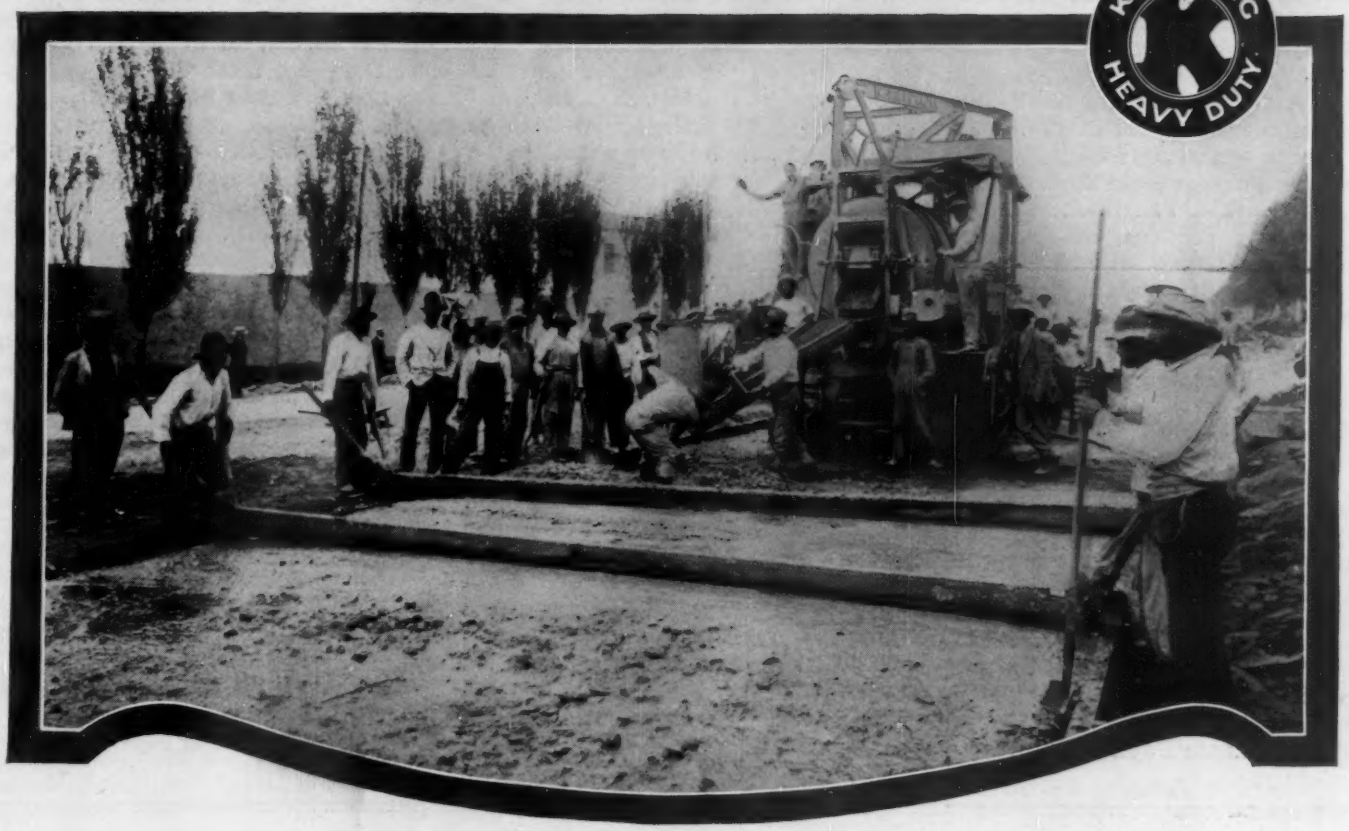

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Chemical Warfare

(*Continued from page 49*)

view to forwarding recommendations concerning the establishment of a unit here. His recommendations went forward on January 25 and on February 2, 1922, the formal application from the Institute to the Adjutant General of the Army was made. This application was approved, but authority for the actual establishment of the unit was withheld provisionally on account of the fact that, though the authorities approved the idea, the necessary funds were lacking. It was contemplated that little additional funds would be required for the unit due to the fact that there were at that time five units already established at the Institute. It was thought that it might be possible to establish the Chemical Warfare Unit along the lines of the Ordinance Unit, which was already functioning and which required but little attention from the Army personnel since the majority of the work was given under the point system, whereby credit for regular courses already in operation at the Institute could be given toward the military course, these courses being along lines very similar to work required by the Ordinance Department. Shortly after the application for the establishment of the Chemical Warfare Unit at the Institute had been forwarded, it was found that other professional schools throughout the country were awakening to the need for units of the Chemical Warfare R.O.T.C., and had forwarded their applications to Washington. With the approval, by the authorities, for the formation of ten units went the communication which held up the establishment of any due to lack of funds. It appeared that the matter would rest here indefinitely, but it was soon found that due to the release of some units of other branches in other institutions in the First Corps Area, it would be possible to establish the first unit of the Chemical Warfare Service R.O.T.C. at the Massachusetts Institute of Technology in the fall of 1924 and authority to so establish such a unit at the Institute was granted by the War Department in a letter of January 4, 1924.

Communication with the Corps Area Chemical Warfare Officer at the Boston headquarters established the fact that this officer was willing, in addition to his other duties, to conduct a series of lectures and demonstrations for the sophomore class during the spring term of 1924. The object of this series was to provide a means whereby the sophomores who, in the fall of 1924, were to become juniors and therefore form the first class of the new advanced unit, could be prepared so that it would be possible to establish a full course, Basic and Advanced, at the same time, thus advancing the work of the new unit one year. This course consisted of a series of 28 lectures and demonstrations in the third term of the sophomore year of 1924. Sixty-five members of the sophomore class signified their desire to join the unit for this basic course and these men were given a general introduction to the Chemical Warfare Service from the military side. Demonstrations were given and a general interest was aroused in the work of the Chemical Warfare Service. From this original 65, at the end of the spring term, 45 signified their intentions of joining the advanced course for the following year.

During the summer of 1924, the work of establishing the schedules of instruction was carried out. It was

(*Continued on page 76*)

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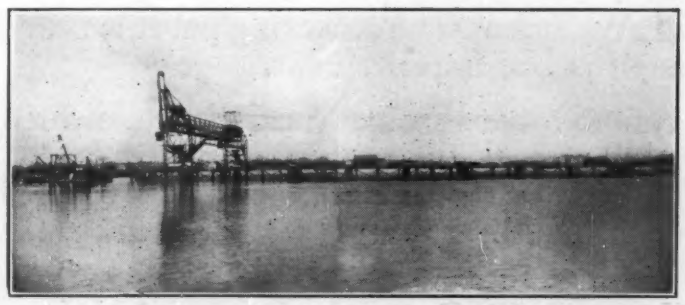

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BETTER LIGHTING NEEDED IN INDUSTRIAL PLANTS.

In a paper read before the Illuminating Engineering Society, February, 1920, entitled, "A Survey of Industrial Lighting in Fifteen States," R. O. Eastman submitted some very interesting data regarding the lighting conditions in industrial institutions. The survey comprises some 446 institutions, in which lighting was considered by 55.4% as being vitally important, and by 31.6% as being moderately important, and by 13% as being of little importance. Practically 58% considered that lighting was as important as power in the operation of the plant, and a small proportion would give more attention to lighting than to anything else.

In considering the present condition of lighting as found in the various plants, only 9% ranked as excellent, about ⅓ ranked as good, 29% fair, 18.8% poor, 3.5% very poor, and 7.8% partly good and partly poor. It was found that the lighting in the offices was far superior to that in the shops; 19% being excellent, 36% good, 31% fair, and only 13% poor and none very poor.

On consulting the executives regarding what factors were most important in considering lighting, the following facts were revealed: Increase of production 79.4%, decrease of spoilage 71.1%, prevention of accidents 59.5%, improvement of good discipline 51.2%, and improvement of hygienic conditions 41.4%. Manufacturers who have good lighting appreciated its value largely from the standpoint of its stimulating effect upon output.

There is no question that any intelligent man who carefully considers the necessity for good lighting in an industrial plant, will agree that it is impossible for a person to do as good work, either in quality or quantity, in poor light as in good light, but yet the result of a careful analysis discloses the fact that only about 40% of industrial plants are furnishing good light to their workers and 60% are operating under poor lighting. It is hard to understand why such a proportion of concerns can be satisfied with a condition which is universally admitted to be a curtailer of efficiency and a prolific causer of accidents. The principal cause of this condition is that those in charge of such establishments have not given the attention to lighting that it demands. They do not know what constitutes good lighting, and in their absorbing interest of other factors of production have overlooked a vital one.

Every safety official should deeply interest himself in the lighting of his plant and insist upon good lighting as much as good goggles, good guards and other necessary accident prevention equipment. Every production manager should insist upon good lighting because the efficiency of the working force is increased by the condition of the lighting furnished. The plant physician should examine the lighting, for eye strain and eye fatigue are directly affected by poor lighting, as is the hygienic condition. Well lighted plants are invariably cleaner than poor lighted places. Plants equipped with Factrolite Glass in all windows are well lighted.

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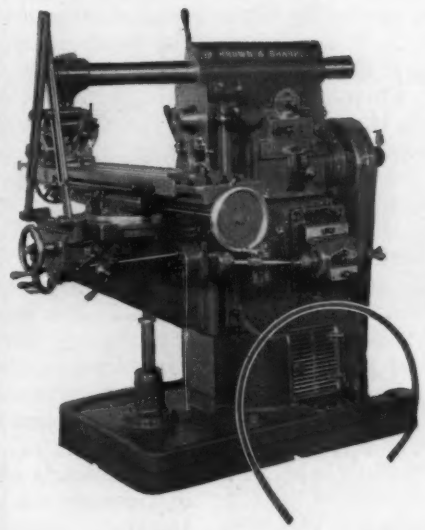

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Chemical Warfare

(*Continued from page 74*)

determined that the members of the unit should be drawn primarily from Course V and Course X at the Institute, these being the men who were peculiarly fitted for Chemical Warfare because they were taking courses which specialized in chemistry. Several members of other courses, particularly XIV and XV-3, who had taken the basic course in the sophomore year, signified their desire to join the advanced unit and this was permitted in order that they might finish the work which they had undertaken. The first tentative schedules prepared and forwarded to the War Department for approval provided only for Courses V and X. Later, authority was obtained to make the members of Course XIV eligible for the advanced unit, and it is at present contemplated that the same eligibility will be extended to members of XV-3 as soon as approval by the War Department can be obtained. Thus four of the courses at the Institute, whose members are all closely related to the chemical profession, will become available as a nucleus upon which the Chemical Warfare Unit may draw and who will, upon completion of the course, become officers of the Chemical Warfare Reserve Corps of the Army. In this way the Reserve Corps will obtain personnel who are well qualified technically for the work they will be called upon to perform and who have received basic instruction in the rudiments of the service side of their profession.

The courses at present arranged for the Chemical Warfare Unit divide the work into four distinct phases.

The Basic course of three hours per week in the last term of the sophomore year introduces the Chemical Warfare Service in a general way and serves to give an outline of its various activities, aims and endeavors.

The chemical side of the future reserve officer's education is taken care of through the regular courses of the Institute supplemented by special courses arranged in options of the regular courses and open only to members of the advanced Chemical Warfare Unit. In these Chemical Warfare options special courses, such as the analysis of Chemical Warfare gases and the manufacture and supply of Chemical Warfare material take the place of more general subjects along the same lines given to the class as a whole in the regular course. These special options cover the work of the junior and senior years.

The theoretical side of the course consists of a series of discussions, practical problems, demonstrations and textbook work covering a period of three hours practical work and three hours preparation work per week for the last term of the junior year and is intended to prepare the student for the work of the summer camp. This work is given by the officer in charge of the Chemical Warfare Unit.

The practical side of the Chemical Warfare Service is taken up during the six weeks encampment held during the summer of the junior year at Edgewood Arsenal, Maryland. Here the student sees the practical application of his Institute work in demonstrations and problems in connection with the First Gas Regiment. He sees the working of the production plants and the small scale laboratories. In this way he rounds out his instruction and upon his return to the Institute for his senior year, continues in the special Chemical Warfare option of his

(*Continued on page 78*)

TECHNOLOGY BRANCH H. C. S.

"--- and when you get out of the Institute forget all of this stuff you have learned here. Buy a good Engineers handbook and learn how to use it."

This remark is credited to a former Technology professor in the Civil Engineering Department.

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Chemical Warfare

(*Continued from page 76*)

course, and in addition, takes up such general studies as the course in International Law and the course in the Military History and Policy of the United States under the P.M.S. and T. No further military work in the unit is carried out during the senior year. Upon his graduation from the Institute, the student is commissioned as a second lieutenant in the Officers' Reserve Corps, and it is felt that upon completion of his course, he is well qualified as a chemical officer of the Chemical Warfare Service. The words "Chemical Officer" are used advisedly, for it should be remembered that the Chemical Warfare Service has two distinct branches, the one in which is conducted the research and development from the chemical viewpoint, the other in which is carried out the actual use of the Chemical Warfare material and the training of the Army as a whole in Chemical Warfare defense.

For the first of these, the graduates of the Chemical Warfare Unit at the Massachusetts Institute of Technology are particularly well fitted.

Power and Beauty of Niagara Falls

(*Continued from page 53*)

vation of the scenic beauty of Niagara as well as being responsible for the great power developments made by the Niagara Falls Power Company under his direction. In order to demonstrate the effect of various diversions on the flow of the water over the Falls and to enable studies to be made of remedial works, Mr. Harper built a large size model of the Falls, a photograph of which is shown herewith. This model is about 100 by 125 feet in plan and at a horizontal scale of one to one hundred. From experiments made on this model, it has been shown that not only could miniature weirs be built which would spread the flow more evenly over the crest of the Falls, but the same effect could be produced by the construction of artificial islands placed in various positions above the brink of the Horseshoe Falls. These islands, if properly treated, would add to rather than detract from the scenic beauty of the surroundings and with such islands in place a much greater increase in diversion of water for power purposes could be made and still maintain an even flow over the Falls, thus not injuring its scenic beauty and at the same time by stopping the concentration of flow at the apex of the Falls greatly decrease its recession.

The benefits inuring from the development of power at Niagara are obvious. Most of us are doubtless familiar with the great aluminum, carborundum and other electro-chemical and electro-metallurgical plants dependent on Niagara for their existence, which together with the general distribution of electric energy make these power developments of such important service to mankind. This great utilization of Niagara's potentialities seems to justify the prophecy of Elbert Hubbard, made shortly before his tragic death:

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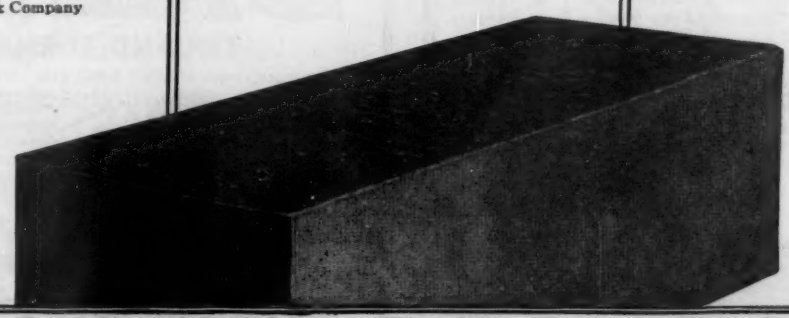

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(*Continued from page 57*)

making such ideals practical and effective in a group of business retailers.

Another interesting activity is represented by the Oil Statistics Co., with a staff specializing on the study of this one industry. Similar in purpose and plan to the company just described, is another organization specializing in metal statistics. The first commodity to be taken up was copper and there have been assembled a large amount of data and analytical studies which are a real contribution to the subject.

One of the oldest financial dailies in America, the *Boston Financial News*, has recognized the great advantage of being in close contact with this growing information depot, and has moved with its valuable reference files to Babson Park. The Publishers' Financial Bureau is at the same time supplying daily and weekly releases on the business situation to the newspapers of the United States and Canada. Through these agencies the facts gathered at Babson Park and the findings derived from them are now being made available to over five million readers.

Annual conferences, attended by several hundred business men from all branches of commerce and industry are already being held each summer, and it is probable that this feature will be developed into a sort of summer session for business executives. Last year the program included addresses by noted experts, followed by round-table conferences on financial subjects, the foreign situation, traction companies and the traffic problem, the labor outlook, business education, retail distribution and fundamental conditions affecting commodity prices and business.

One of the most striking features of the whole development is the large fireproof building to house the Great United States Map and Financial Library. In this work a number of important business and scientific institutions are co-operating, including the United States Government. A special brick and cement building is being erected to house this great relief map and the vast amount of subsidiary maps and charts which will accompany it. On the floor of the center section of this building is the great map itself, 64 feet long, covering 3,500 square feet. The map is being constructed in relief. All the hills and mountains, plains, rivers, lakes and shores are being so constructed and painted as to show the surface of the earth in just as naturalistic a manner as possible. Even the earth's curvature is represented, it being equivalent to the United States section of a globe 166 feet in diameter.

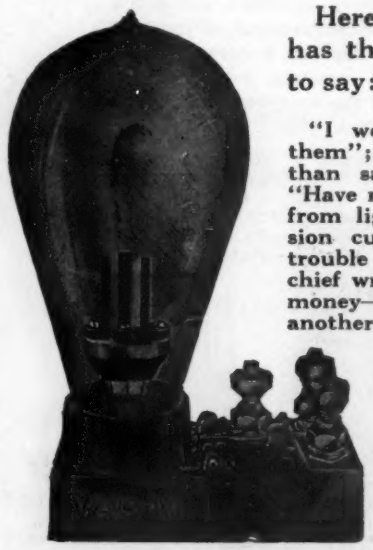
It will be the largest map of the United States in existence. This map will represent, in very truth, the economic resources, the industrial activities, the social conditions, the weather, and many other aspects of our daily life.

On the map will be shown developed and undeveloped water powers, rivers, forests, agricultural lands, mineral resources, etc.; also railroads, interurban traction lines through highways, canals and waterways, as well as centers of industry and population, states and cities. Supplementing this great map, in an adjoining section of the building, will be a most complete collection and exhibit of detailed sub-

(*Continued on page 82*)

VAC-M Arresters Will Protect Fire Alarm Apparatus

against lightning and other electrical disturbances.



Here's what a chief who has them in service has to say:

"I would not do without them"; another writes, "More than satisfactory"; a third, "Have never had a fuse blown from lightning or high tension current"; another, "A trouble saver"; still another chief writes, "It has saved us money—fine results"; and another chief writes, "The installation has been very satisfactory. We have standardized on this equipment, and will equip any future installations in the same manner," etc.

The National Electric Specialty Co.
Toledo, Ohio

Quality—Service

Black and Galvanized
RUST-RESISTING
SHEETS
TIN AND TERNE PLATES

We manufacture SHEET AND TIN MILL PRODUCTS for all purposes — American Bessemer, and American Open Hearth Steel Sheets, Keystone Copper Steel *rust-resisting* Sheets, Apollo Galvanized Sheets, Formed Roofing and Siding Products, Culvert and Flume Stock, Sheets for Special Purposes, Roofing Tin Plates, Bright Tin Plate, Black Plate, Etc.

AMERICAN SHEET AND TIN PLATE COMPANY, Frick Bldg., Pittsburgh, Pa.
Every engineer should have our booklet describing Keystone Copper Steel.

Rust-resistance

Bell and Spigot Joint

THE Bell and Spigot Joint for Cast Iron Pipe, adopted over one hundred years ago, is the preferred joint today.

It is tight, flexible, easily made and non-corrodible. There are no bolts to rust out. It makes changes of alignment or insertion of special fittings a simple matter. It can be taken apart and the pipe used over again, without any injury. It is not subject to damage in transit. In fact, it embodies practically all of the desirable qualities in an underground joint.

The use of this type of joint, together with the long life of Cast Iron Pipe, makes for extremely low maintenance costs.

THE CAST IRON PIPE PUBLICITY BUREAU
Peoples Gas Bldg., Chicago

CAST IRON PIPE

Our new booklet, "Planning a Waterworks System," which covers the problem of water for the small town, will be sent on request

Send for booklet, "Cast Iron Pipe for Industrial Service," showing interesting installations to meet special problems

THE science of the designer is best expressed by high quality of materials employed in production. A good design worked out with poor materials is as though a student devoted years of effort to studying worthless and obsolete text books.

In this day, when many parts already manufactured are often incorporated into a product, the engineer should know those firm names which are synonomous with terms of quality.

THE BUNTING BRASS & BRONZE CO.
TOLEDO, OHIO

New York Boston Chicago Philadelphia
Cleveland San Francisco

"It pays to make the best of it."
Baby Bunting

BUNTING
PHOSPHOR BRONZE
BUSHING BEARINGS
PATENTED

The Way Up

(*Continued from page 47*)

speech the Democratic party stood for "Rum, Romanism and Rebellion." Another vice-president of the company is Mr. Charles Patterson, who, when I was in Schenectady the time before, was superintendent of the Methodist Sunday School. He is now located in New York City. The treasurer, Mr. Darling, taught a Bible class in the Presbyterian Church. The general manager, Mr. Dalton, had just been made president of the local Y. M. C. A. Mr. Manning, the general superintendent, who has just retired, sent me word that he was sorry he could not attend the meetings at which I spoke, because he had another engagement. He wanted me to know, however, that he was in sympathy with everything for which I stood. Mr. Bliss, the head chemist, cross-questioned me like a Philadelphia lawyer as to the best way of conducting a men's Bible class.

This was the kind of EXCEPTION TO PROVE THE RULE that the General Electric Company at Schenectady happens to be!

When the Advertising Clubs of the world met at Atlantic City, I was asked to make the opening address in the Industrial Section. Instead of taking the technical subject which was assigned to me, I thought it

(*Continued on page 84*)

Babson Park

(*Continued from page 80*)

sidiary maps, charts, and graphs showing the details of states, counties, and cities.

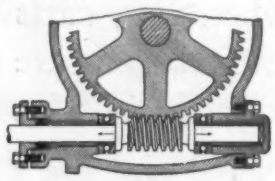
The large financial library will be in a section of the map building, adjoining the map itself. This library is now being brought together and will be the largest of its kind in existence. It will contain a description of all mortgage bonds of railroads, public utilities, and industrials, and the properties on which these mortgages are placed. It is planned to have key numbers to these descriptions so that the position of any section of a railroad, traction, or power company can be seen on the great map and the subsidiary maps. This will be of very special value to investors as well as to the companies themselves.

And so there is developing month by month this interesting and valuable business laboratory. What the International Institute of Agriculture at Rome is to agriculture, the Babson Institute and its related organizations should be to business. The hill which is in the center of the "campus" will be crowned with state and national buildings and the great statistical building. These will not only contain the statistics for the various states and countries, but each will provide quarters where state officials may come for a month or a year to study the future of his state or nation. Near these will be locations where the different trade associations, labor and other organizations, may have their buildings, while outside the Institute Campus may be buildings for study and research erected and owned by large corporations and business interests.

With its close proximity to Boston and at the same time situated in the beautiful and healthful hills of Wellesley and Needham, it occupies an enviable position. Its slogan—"Largest Statistical Community in the World" seems justified, and the wisdom of its founder is amply demonstrated by the outlook.

WORM DRIVES
operate smoothly with
AUBURN THRUSTS

The use of Auburn Ball Thrusts with their minimum of wear and constant thickness insures the least amount of backlash, and avoids jerky starting and stopping of the worm drive.



Auburn Thrusts prolong the life of both worm and gear and make a smoother operating machine.

Steel, Brass and Bronze Balls
Ask for *Auburn Data Sheets*
AUBURN BALL BEARING CO.
44 Elizabeth Street
ROCHESTER, N. Y.
Trade Mark

BUFF Instruments
save time—error—calculation

Engineers and contractors know that BUFF performance is accurate and sure—on all sorts of work from running location lines to giving "neat lines" on important bridgework—without having to adjust the transit once.

Write for the BUFF Catalog No. 20M

Buff & Buff Mfg. Co.
Jamaica Plain, Mass.

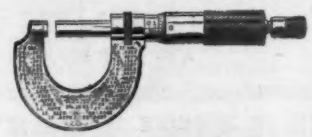
BUFF

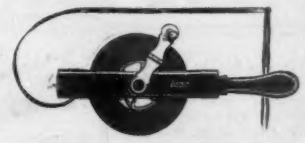
LUFKIN TAPES—RULES TOOLS

All of Superior Quality and of Interest to Every Progressive Engineer

Send for
Cat. No. 11—Tapes and Rules
Cat. No. 3—Tools

THE LUFKIN RULE CO.
SAGINAW, MICHIGAN
NEW YORK WINDSOR, CAN.





Granite Paving Block Manufacturers' Association of the United States, Inc.

31 STATE STREET, BOSTON, MASS.

MEMBERS

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ARABIA GRANITE CO., 108 Bell Block, Cincinnati, Ohio

BOOTH BROTHERS AND HURRICANE ISLE GRANITE COMPANY, 208 Broadway, New York

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SALISBURY GRANITE CO., Salisbury, North Carolina

STONE MOUNTAIN GRANITE CO., Stone Mountain, Georgia

WAUSHARA GRANITE QUARRIES CO., 133 West Washington Street, Chicago, Ill.

PLUTONIC GRANITE BLOCKS

IN order to meet an increasing demand for a block with all the wearing qualities of the standard granite blocks but without the refinements of cutting required by the specifications of the American Society for Municipal Improvements blocks are now being made called Plutonic Granite Blocks. These blocks vary greatly in size and lay from 25 to 40 to the square yard. They cost about one-half the price of the standard blocks and are used for State Highway Construction.

Durax Granite Cube Paving

Durax paving blocks are cubes of granite with six approximately square surfaces, the edges of which measure not more than 4 in. nor less than 3 in. in length. The blocks are hand cut from the best granite stock and are irregular in both size and shape in order that they may be paved in concentric arcs of circles and still lay with a close joint. The largest cubes are laid at the top or center of the arc and smaller cubes at the springing line.

Durax is usually laid on a 4 to 6 in. concrete base with a 2:1 sand-cement cushion and an asphaltic-mastic joint filler, noiseless, dustless, sanitary, and, when properly laid, will withstand any traffic weight.

The Standard Paving Blocks

Trade Name of Block	Length		Width		Depth	
	From	To	From	To	From	To
Five inch	8"	12"	3½"	4½"	4¾"	5¼"
Four inch	7"	11"	4 "	4½"	4 "	4½"
Resurfacing	7"	11"	3¾"	4¼"	3½"	4 "
Hassam Bl.	6"	12"	3½"	4½"	4 "	4½"
Manhattan	6"	10"	3½"	4½"	4¾"	5¼"

The five-inch block is now the United States standard granite block size developed by the co-operative effort of the paving engineers of the nation and the manufacturers. It is the heavy-traffic standard and any variations from this type and size are special sizes and, while they have no added benefits cost more than the standard to make.

The four-inch and the resurfacing blocks have been developed to meet the demand for a granite block slightly shallower than the standard, which could be used to replace worn-out pavements of other types where the concrete base still was in good condition. The four-inch type and Hassam are in very common use, but the resurfacing block is harder to make and is a special block not carried in stock by the manufacturers.

Granite Curbing

The manufacture of granite curbing stones is very simple. Large blocks of granite are quarried to dimensions which are multiples of the length, width and depth of the desired curbstones. This quarry consists of drilling lines of holes in four directions, inserting wedges in the holes and splitting out the large block of granite by driving home the wedges until the pressure causes the stone to split out from the mass of quarry.

These large blocks of granite are then lifted out of the quarry with derricks and loaded onto flat cars which transport them to the cutting shed.

On arrival at the cutting sheds they are split into rock-faced curbing by the use of wedges.

The quarryman taps the wedges lightly with a hammer until the pressure overcomes the resistance of the stones and the break occurs.

This product is called rock-faced curbing. It is inexpensive and is widely used for curbing for city, parkway and suburban improvements. The cost of curbing is controlled by the amount of work that must be done by high-priced stonecutters after the rock-faced curb is made.

If further finishing is required by the specifications the quarry-faced curb is blocked up on the bankers and expert stonecutters finish it to comply exactly with the requirements of the particular city or town for which it is intended.

There are five standard finishes for curbstones:

1, Rock-faced; 2, Rough-pointed; 3, Fine-pointed; 4, Peanhammered; 5, Four-cut Patenthammered.

Illustrated literature furnished on request.

The Way Up

(*Continued from page 82*)

would be helpful to the men who were in the advertising game to call attention to the kind of men at the head of the concerns where they expected to sell the goods which they were advertising. So I investigated purchasing agents a little bit and made this discovery: I found that every one of the great concerns spending millions, when they come to select the man for the tremendous position of purchasing agent did not go to the Great White Ways, to the cabarets, to the pool rooms, to the racetracks, to the card tables, to the loafing places or other such resorts to get their man. *In every case they went to the church and Sunday school for him.*

For example: the purchasing agent of the great Pennsylvania Railroad, Mr. Porcher, is active in the Episcopal Church. Another purchasing agent, Mr. Grone, who has since gone into business for himself, is superintendent of a Christian Sunday school in Philadelphia. The purchasing agent of the United States Steel Company, Mr. Millar, is a man who goes out and makes religious addresses. The purchasing agent of the Bethlehem Steel Company, Mr. Holton, is an elder in the Presbyterian Church and a teacher in the Sunday school. The purchasing agent of the United Gas Improvement Company, Mr. Pearson, is a vestryman in the Episcopal Church, and his assistant, Mr. Hubbs, is a trustee in the first Presbyterian Church in Germantown. The purchasing agent of "Heinz, 57 Varieties," Mr. Kober, teaches a Sunday school class in the Methodist Church. The purchasing agent of the International Harvester Company, Mr. MacDonald, is also an active Sunday school man. Some time ago, I had Mr. A. C. Bedford, the head of the Standard Oil Company to dinner with me, and we were discussing this very matter. I asked him how it was with the 34 subsidiaries of the Standard Oil Company, and he replied, "So far as I know, the same thing holds true."

Up to the present time I have not found a single large concern with a profane, Godless purchasing agent. I knew of one large concern, the very largest in its particular line, whose

(*Continued on page 86*)

for Insulation

CORK BOARD
PIPE COVERING
GRANULATED CORK

American Cork Co., Inc.
16 BLACKSTONE STREET BOSTON, MASS.

The Tech Engineering News

is the Professional Journal of the Undergraduates at the Massachusetts Institute of Technology.

is published monthly, October to May, and contains Articles of general Scientific and Engineering Interest besides many of Institute Activities.

is desirous of having You upon its Mailing List. Subscription Price is $1.50 but check does not need to accompany order. Use this Coupon.

Name .....

Address .....

.....

Founded 1878 — OKONITE — Incorporated 1884

TRADE MARK.

The Standard for Rubber Insulation

FOR 45 years the name "Okonite" has stood for the highest quality of Electrical Insulation for Wires and Cables.

"Okonite" itself is a rubber compound never containing less than 30% by weight [over 60% by volume] of high grade Para Rubber with absolutely no admixtures or substitutes.

All products bearing the Okonite trademark carry with them our unconditional guarantee of excellence and unvarying reliability.

Okonite is made in but one grade.

THE OKONITE CO., Passaic, N. J.

Sales Offices:
NEW YORK CHICAGO PITTSBURGH ST. LOUIS ATLANTA
BIRMINGHAM SAN FRANCISCO LOS ANGELES

Agents:
The F. D. Lawrence Electric Co., Cincinnati, Ohio
Pettingell-Andrews Co., Boston, Mass. Novelty Electric Co., Philadelphia, Pa.
Canadian Representative: Engineering Materials, Ltd. Montreal

The Rollers That Put The Roll In Rolling Stock

WITH the advent of the automobile, Hyatt roller bearings became essential parts in promoting continuous ease of running and freedom from repairs for transportation and farm equipment. The Haynes-Apperson, credited as the first commercial gasoline car, had Hyatt bearings built into it.

The development of the automobile industry and the increase in the use of the automobile has been rapid, and equally rapid has been the multiplication of uses and applications where Hyatt bearings play an important part.

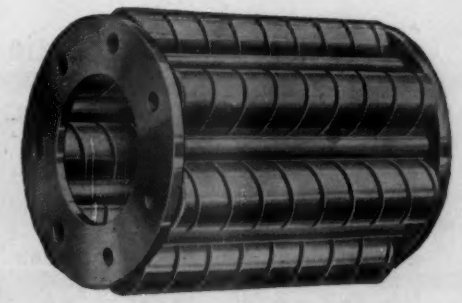
From the humble lawn mower to the haughty motor car, from the finely adjusted motor to the rough and ready logging block and ore conveyor, from the lightly turning windmill to the pounding railroad car, in all fields of activity, Hyatt bearings are vital factors for efficient and economical operation.

The simple, sturdy construction of these bearings gives long life free from worry about breakdowns or replacements. The easy rolling motion and absence of rubbing friction eliminate the danger of overheating and insure longer life to the bearings and enclosing parts. At the most they require oiling only three or four times a year, permitting not only worthwhile savings in oil but also maintenance and inspection costs.

Steady advances are being made in the application of Hyatt bearings to every field where uninterrupted and economical production are important factors. Our engineering and research departments are always ready to cooperate with you in solving your bearing problems. Make a note of our address now for future reference.

HYATT ROLLER BEARING COMPANY

NEWARK, NEW JERSEY



If you will drop us a line, mentioning the name of your college, we will send you a small Hyatt bearing which you may use as a paper weight or a pocket piece. This will give you a clearer idea of the unique construction which makes the Hyatt roller bearing durable and reliable.

The Way Up

(*Continued from page 84*)

owner made the boast that he had everything in his cellar fit for a man to drink. When he came to select a purchasing agent, he selected a Baptist Deacon. I asked him why he did not select one of his own kind. He said, *"that would not be good business."* Do you get it?

Some time ago a professor of the Bryn Mawr Woman's College broke into the newspaper with the statement that 80 per cent of the scientific men of the country did not believe in the immortality of the soul. That is a highbrow way of saying "have no religion." I asked the president of the University of Pennsylvania, himself a great scientific man, Dr. Edgar Fahs Smith, "Is this true?" He replied, "The statement is ridiculous and pay no attention to it." Just for instance, the greatest doctors in this land are Christian men, the Mayos of Rochester, Minn., and Dr. Kelley of Baltimore. These are the greatest of doctors, to whom other doctors themselves go when something goes wrong with them.

I wrote to the editor of the Philadelphia *Ledger*, in which the statement appeared, stating that whether the claim of the Bryn Mawr professor was true or not, I would like to call the *Ledger's* attention to the fact that right alongside of the Bryn Mawr Woman's College was the Bryn Mawr Presbyterian Church. The men who were at that time officers of that church, and who were men who made two blades of grass grow where one grew before, and who gave employment to thousands and thousands of the men who make the happy homes in and around Eastern Pennsylvania, all believed in the immortality of the soul. Some of the officers of that church were the following:

Mr. Samuel Rae, president of the Pennsylvania Railroad, was a trustee. Mr. William Patton, his assistant, was also a trustee. Mr. Alba Johnson, then president of Baldwin Locomotive Works, was an elder in that church. Mr. William Austin, chairman of the Board of the Baldwin Locomotive Works, was an elder. Mr. Sylvester Marvin, head of the National Biscuit Company, was an elder. Mr. Pew, head of the Sun Oil Company, was another elder. Mr. William Steen, the treasurer of the DuPont Company, another elder; Dr. Wilbur, the chocolate manufacturer, another elder. Mr. Chas. Ludington, secretary and treasurer of the *Ladies' Home Journal, Saturday Evening Post, Country Gentleman,* etc., was a trustee in that church. Mr. Frank Roberts, the great blast furnace engineer, was a trustee.

So we could go on telling of others, filling this whole magazine with statements of facts such as the above, but what has been written is sufficient to cause any sensible young fellow to sit up and take notice.

Just as I write this article, Mr. Walter S. Gifford has been made president of the American Telephone and Telegraph Company. When I saw the announcement in the paper, as is my custom when a new man comes to the top, I wrote and asked him how about it? He replies, "I was brought up in the Christian Church and am still a Christian."

Lots of people do not know that Judge Gary, the head of the United States Steel Company, the world's greatest corporation, is a Methodist and used to be a Sunday school teacher in the Methodist Sunday School. Mr. Farrell, the president of the United States Steel Company, is an earnest Roman Catholic, as is Charles Schwab, the head of the Bethlehem Steel Company.

Any young fellow who thinks it is smart to be profane and sporty simply "breaks his merlassus jug," as Uncle Remus would say.

So in closing we want to say, as we said when we began, no man ever gets very far in this world to stay, who does not STAND IN WITH THE CAPTAIN!

Selected Grades

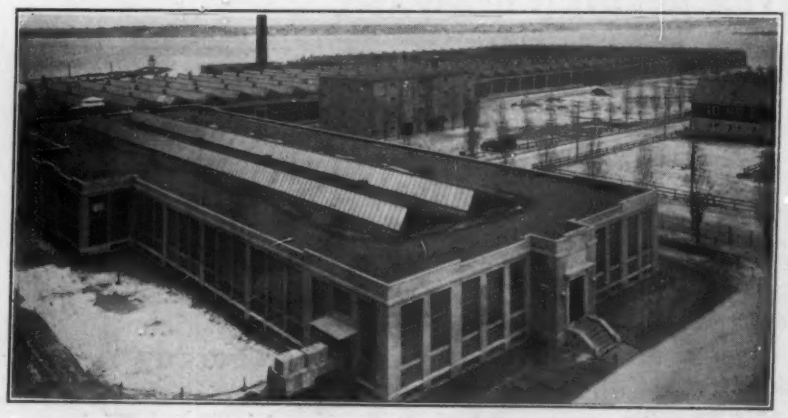
Anthracite

and

Bituminous

COAL

BURTON-FURBER
COAL COMPANY
50 CONGRESS STREET
BOSTON



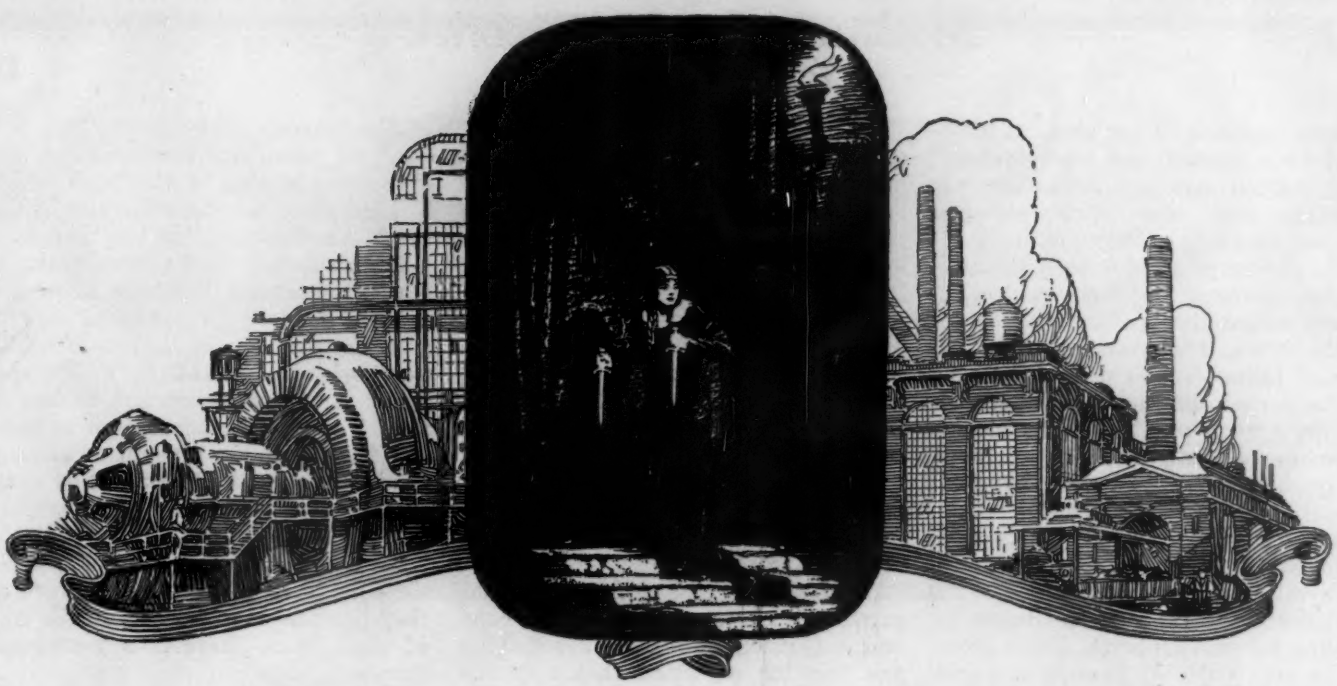
One of the finest textile mills in world built by Wm. T. Reed Co. Several repeat orders have been received from this firm

WILLIAM T. REED CO.

Building Construction

200 DEVONSHIRE STREET, BOSTON

We are organized and equipped for the efficient handling of mercantile and industrial building construction of all descriptions



"THE PLAY'S THE THING"

JOHN BARRYMORE himself would "get the hook" if he did not know his cues, or read his lines as called for by the action of the play.

Engineers get cues, too—from the industrial drama of which they are a part. Like actors, their performance must fit the action of an economic play.

Thus the reason that the journals, the societies, the schools, colleges, teachers, and well-known public men, are urging engineers to study economics—to learn the nature and effect of economic laws.

To build the largest generator or the smallest meter, for example, is not always in itself a great engineering feat. The feat consists in having it ready at a time, a price, and with such features as the prevailing economic situation calls for.

In this sense engineers—and particularly Westinghouse engineers—must be "practicing economists". They must follow closely the "action of the play"—analyzing fundamental conditions in every field, and calculating their causes and probable effects.

All this, so that when a cue is spoken in factory or home, on farm or railroad, on the sea or in the air, they may be ready.

This advertisement is eighth in a vocational series, outlining the fields for engineering achievement in the Westinghouse organization. A copy of the entire series will be sent to anyone requesting it.

Westinghouse

WESTINGHOUSE ELECTRIC

ACHIEVEMENT & OPPORTUNITY

Modern Testing of Firebrick

(*Continued from page 58*)

amount, perhaps 10 per cent, as indicated by a pointer and lever system. This method has the advantage of showing how the brick softens, whether suddenly or very gradually.

The ability of a brick to withstand sudden changes in temperature is usually called the spalling resistance of the brick. The resistance to this type of failure varies with a number of the various physical properties of the brick such as the co-efficient of thermal expansion, co-efficient of thermal conductivity, specific heat, density, porosity, mechanical strength, structure of the brick such as fine or coarse grain, amount of grog, etc. A number of investigators have developed tests to indicate the relative resistance to spalling for various brick. These practically all consist of heating one end of the brick to some definite temperature varying from 1562°F. to 2900°F., and after holding at that temperature for some time, the brick is suddenly cooled either by immersing in water or cooling in an air blast. This cycle is repeated until the brick has lost a certain percentage of its volume and the number of cycles to produce this effect is an indication of the relative spalling resistance of the brick. The temperature at which this test should be run depends upon the temperature expected in practice.

It might be interesting to note that some firebrick have been heated to 2460°F. on one end and then immersed in cold water, this process being repeated twenty times before the brick spalled to any considerable extent, while other brick broke in half after the first immersion.

There has been considerable investigation as regards the resistance of fire brick to slag action. These tests have developed along slightly different lines. In one case a mixture of the slag and ground brick is molded into a cone and the fusion point determined. This test has the objection that only the melting point is determined and no idea of the cutting action or absorption of the slag by the brick is found. Another test is made by blowing powdered slag upon a heated specimen of brick, the volume of this specimen being determined before and after treatment. The relative reduction in volume is used as an indication of the slag resistance of the brick. This test does not take into consideration the absorption of slag by the brick which in some cases increases the size of the brick. Another test that has been used quite extensively in the Heat Measurements Laboratory has been to pour a definite quantity of powdered slag in a given time over the surface of a full-sized brick heated at 2700°F. The specimen is then removed and broken in half. The amount of erosion is measured and also the amount of absorption of slag in the brick. All of these slag tests will vary with different slags and the temperature.

As a rule, firebrick are not fired in the kiln to as high a temperature as they must meet in service. In the case of some brick there is a permanent change in linear dimensions sometimes expansion, and sometimes shrinkage, that follows after they have been in service a short time. In the case of shrinkage, the joints are opened up, exposing the brick to worse conditions as regards temperature, spalling and slag action. In the case where brick expand permanently, there is not se-

(*Continued on page 90*)

The Massachusetts Institute of Technology

SUMMER SESSION

Undergraduate Instruction and Special Courses

THE Summer Session offers to students not regularly enrolled at the Massachusetts Institute of Technology a number of special and regular courses. Among the special courses may be noted those for teachers in high, preparatory and vocational schools —the courses being given in biology and public health, mathematics and general science. Regular courses of the winter terms are given in the Summer Session beginning at various periods in June, July, August and September: (1) to provide an opportunity for students of collegiate grade at other universities or technical schools to anticipate winter courses with a view to later entrance at the Institute with advanced standing; (2) to permit students to supplement or make up work of another university where desired summer courses are not given; (3) to permit regularly enrolled students at the Institute to anticipate or repeat undergraduate courses required in their curricula. During the Summer, the Institute likewise operates Summer Camps at East Machias, Maine, and Dover, New Jersey: the former for field instruction in Surveying and the second for field instruction incidental to Mining Engineering. These courses are primarily for Institute undergraduates, but a limited number of other applications will be entertained.

Entrance Subjects are offered during the Summer Session in mathematics, physics, chemistry, English, French and German. Passing grades in these subjects will be accepted in lieu of formal entrance examinations.

For Descriptive Literature and other Particulars Address The Registrar, Massachusetts Institute of Technology, Cambridge, Mass.

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(*Continued from page 55*)

cover pulverized fuel firing which has been adopted for this station, indicate a necessity for only thirty-two boilers of approximately 15,000 square feet heating surface. These, operating at the higher rating made necessary by the fewer boilers, will produce at their average rating (at which they will be required to operate 62½ per cent of the time) 1.5 per cent higher efficiency than would have been possible with the forty-four boilers at the lower average rating that would have been required. This consideration of modern equipment in this plant made a capital investment reduction of approximately $4,000,000 on the boilers and boiler accessories alone, and this does not take into consideration the saving made in very high-priced real estate.

It is quite possible that in many plants where new boilers are contemplated, the addition of the fin furnace would permit much higher ratings and efficiencies, so that the purchase of the additional boilers might be postponed for several years to come.

Some question has been raised as to the effect the welding of the fins might have on the strength of the tube. We have made numerous tests on finned and unfinned tubes and find that there is practically no reduction in the strength of the tube due to the welding of the fin. The writer just recently saw a hydrostatic test of a 4″-6 gage tube, 4 ft. long, on two feet of which, fins had been welded and the other two feet being plain. The pressure was run up to 6000 lbs. per square inch when a leak developed in the end plug but no bulge or rupture occurred anywhere in the vicinity of the fins. The standard rupture test for a tube of this type is 6200 lbs.

As stated in the beginning of this paper, we do not feel that there is sufficient data available at the present time to warrant us in coming before you with a technical paper covering the fin furnace. We do believe, however, that the fin furnace is a practical operating proposition presenting opportunities for increased capacity, greatly reduced maintenance with equal, if not better efficiencies, and has many other advantages, such as reduction of outage as stated before, and that where additional capacity is required in old plants, no cheaper way can be found to produce it than through the application of fin furnaces to existing boilers.

A New Glass. A new kind of glass, of organic origin, which is reported to permit the passage of ultra-violet rays, has recently been perfected by two Austrian scientists, Herr Pollak and Herr Ripper. The new glass is called Pollopas, and is made by the chemical condensation of urea with formaldehyde.—*Scientific American.*

Firebrick

(*Continued from page 88*)

rious trouble, if the expansion is small, because the brick are usually plastic enough at the furnace temperature to take care of this expansion without damaging the brick structure. In order to meet this condition, a reheating or shrinkage test has been used in which the brick are heated to some definite temperature 2500°F. to 2900°F., depending upon the particular service condition, and held there for five hours. At the end of this time the brick are removed and the change in dimensions measured accurately.

There are numerous other tests that are made upon firebrick for special purposes such as porosity, thermal expansion, thermal conductivity, specific heat, mechanical strength, uniformity of dimensions, etc., but with the exception of the thermal conductivity test, these are relatively simple tests and are not a source of much trouble to the investigator.

In the last few years, there has been an interesting development in regard to the microscopic study of firebrick which may in time be as useful in determining the properties of a brick as it has for steel and other metals. There are also possibilities that X-Ray analysis may prove an aid to the study of the various properties of brick.

The tests that have been described above are not, in general, standardized and undoubtedly as this experimental work in refractories continues, these tests will be improved or replaced by new tests so that in time the consumer will be able to predict in advance the best firebrick for his particular purpose. The life of refractories is now, frequently the limiting factor in regard to possible furnace temperatures, and production; consequently there is much interest in this laboratory testing at the present time. There is no doubt that the quality of fire brick has been notably improved since the work on testing has been started, and since this work has practically all been developed with the past ten years, the future for better refractories is very bright.

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